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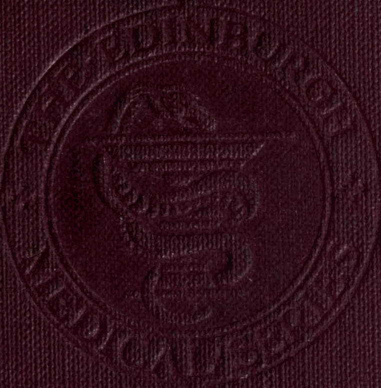

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M.A., B.SC., M.D., F R.C.P.E.

GENERAL PRACTICE AND X-RAYS

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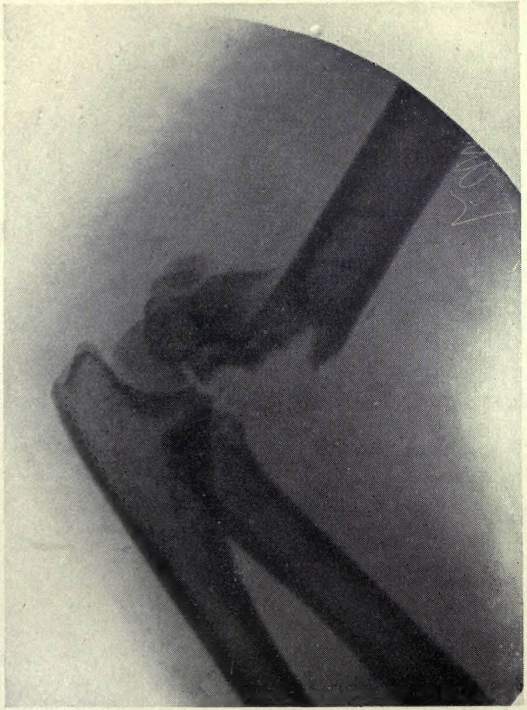
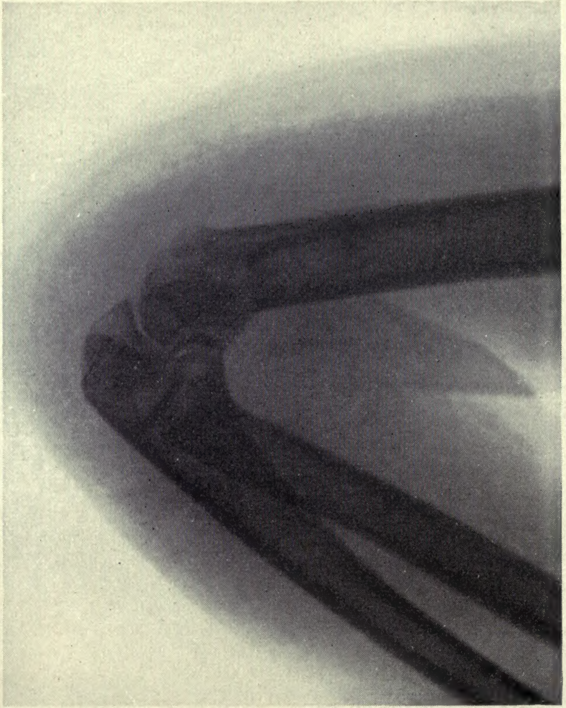
PLATE I.



Fracture of lower end of humerus with backward displacement of the elbow-joint.



The same joint after reduction and fixation ; this is a striking example of the value of radiography as an aid to the surgeon in dealing with difficult cases.

(By kind permission of A. J. Walton, Esq., F.R.C.S.)

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GENERAL PRACTICE AND X-RAYS

A HANDBOOK FOR THE GENERAL PRACTITIONER AND STUDENT

BY

ALICE VANCE KNOX

M.B., B.CH.

WITH CHAPTERS ON THE PRODUCTION OF X-RAYS
AND INSTRUMENTATION BY

ROBERT KNOX

M.D., C.M., M.R.C.S., L.R.C.P.

*CONTAINING THIRTY-TWO PAGE PLATES AND
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DEDICATED TO

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HONORARY RADIOLOGIST, ROYAL INFIRMARY, LIVERPOOL

THE VALUE OF WHOSE PIONEER WORK IN RADIOGRAPHY

IS UNIVERSALLY ACKNOWLEDGED

PREFATORY NOTE

THIS volume owes its inception to Dr. John D. Comrie, the Editor of the series, who suggested that such a book would be found useful by the General Practitioner. My thanks are due to him for valuable suggestions made regarding the arrangement and scope of the volume.

My thanks are also due to Mr. Alex. Mackay, B.A., for reading and criticising the MS.

I wish especially to thank Mr. H. A. Low and Dr. Robert Knox for their invaluable help in the arrangement of the book, the compilation of the Index, and the selection of illustrations. Without their co-operation the book could not have been written.

To the Publishers I would express my cordial thanks for the excellent manner in which they have supervised the production of the illustrations and for their courtesy and attention during the progress of the work.

A. V. KNOX.

HIGHGATE, *September* 1, 1920.

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PART I

RADIOGRAPHY AND THE GENERAL PRACTITIONER

By Alice Vance Knox, M.B., B.Ch.

INTRODUCTORY

The science and practice of radiography and radiotherapy have developed so rapidly since the discovery of the new rays, and more particularly during the last decade, that it is not an easy matter for the general practitioner to keep pace with these developments and to appreciate to the full either the help they can afford him or their limitations. Especially is this the case with the older practitioner, who was already in full work when Röntgen published his discovery in 1896. The young practitioner just qualified and starting practice is familiar with X-rays, can speak familiarly of radiographs and prophylactic treatment, and is perhaps too prone to rely upon radiography to establish a diagnosis, instead of making the careful physical examination of earlier days.

Between the man who looks upon X-rays as something of a mystery and scientific plaything, useful to reveal the bones inside their fleshy envelope, and the man who tries to use X-rays to disguise his lack of real and essential knowledge, is the practitioner who recognises that the new science is a very powerful agent to help him in his daily fight against disease, an agent which, applied in a case where a thorough physical examination has been made and all possible data collected and considered, is often of the greatest use in establishing a diagnosis or treating a condition.

It is for this type of practitioner that the present volume has been written, in the hope that a general survey of the subject by a General Practitioner may be a helpful guide to him in his daily work, and lead to a full appreciation of the value of X-rays in diagnosis and treatment.

The practitioner who is engaged in a busy practice has little time in which to familiarise himself with the rapid developments of new medical science, and yet he is the man who first, in his daily rounds, comes across the patients to whom these new developments offer enhanced chances of relief and cure, and therefore it behoves him to keep himself *au fait* with all advances and cultivate an elementary but working knowledge of their uses and practical application.

Especially is this the case with radiography and radiotherapy, and it is to meet this need of the general practitioner that this book is written.

The limits of the volume are confined to a practical demonstration of the value of X-rays in general practice, and to a short description of the conditions in which they will be found to be of use.

It is not intended to convey a working knowledge of X-rays by means of which the practitioner may himself employ the new agent, but, in the chapters on Instrumentation, points in technique of which the practitioner should be cognisant will be described.

The illustrations are reproduced from negatives which have a value in diagnosis, and should serve to indicate a number of conditions, met with in practice, in which an X-ray examination will be useful.

THE RELATION OF THE GENERAL PRACTITIONER TO THE RADIOLOGIST

The time has gone by when the radiographic expert was looked upon as a special kind of photographer, who took a plate—and "there an end!" He should be, and for the most part is, a medical man of experience in the clinical diagnosis and pathology of the conditions which he demonstrates radiographically, and his opinion is of value not only in the interpretation of plates but also in the diagnosis of the condition and in the prognosis.

The thorough examination by radiography of a morbid lesion in any organ of the body leads to an appreciation of the extent of the mischief, and in this way an opinion may be formed as to the future of the patient. It is thus that an X-ray examination may be of much use in prognosis.

It follows, therefore, that the relation between the general practitioner and the radiographic expert is that which exists between the practitioner and the consulting physician or surgeon. The general practitioner is for the most part quite unpractised in the interpretation of X-ray plates and of the picture shown in screening operations. He has, as a rule, no knowledge of the normal radiographic appearance of anatomical structures, and therefore cannot appreciate variations from the normal, save in cases of very gross lesion such as a comminuted fracture with displacement of the fragments of the shaft of a bone. It may confidently be stated that a survey of the radiograms of a complete bismuth examination of the alimentary tract will leave the average general practitioner quite in the dark as to whether or not there is disease present, and yet the bismuth meal examination is daily becoming of more importance and value in the diagnosis of abdominal conditions. Or again, to quote another common example, in how many cases is the general practitioner able to distinguish a phlebolith from a stone in the ureter, or to appreciate the first faint indications of tubercular disease of the hip-joint ?

There are instances in which only highly trained skill can interpret the appearances presented on a plate ; these serve to emphasise the need for special training. There are many more obvious conditions in which even the uninitiated can detect departures from the normal. If the practitioner desires to understand the records of a radiographic examination, it is essential that he familiarise himself with the appearances of normal conditions, and the obvious deviations from the normal, before he attempts to deal with more intricate problems.

The position of the radiographic expert is essentially that of a consultant. It follows, therefore, that it behoves the general practitioner to acquaint himself with all the points to which attention is necessary in order that a radiographic examination may result in the greatest possible amount of satisfaction and benefit to the radiographer, the practitioner, and the patient.

These points are :

(1) The radiologist should be made fully acquainted with the history of the case and the existing physical condition of the patient.

(2) In cases where special technique is required the patient should be properly prepared

for the examination, as regards previous dieting, clothing, purgation, etc.

(3) The patient should be mentally prepared for the examination; that is, he or she should be informed of the necessity or otherwise of undressing, of the probable length of the examination, of the possibility of several visits having to be paid on one or more consecutive days (as in a complete opaque-meal examination), and, in the case of treatment, should be warned as to possible temporary after-effects, and instructed regarding the best steps to take to minimise these effects.

CHAPTER I

THE SPHERE OF USEFULNESS OF X-RAYS IN GENERAL PRACTICE

THE sphere of usefulness of X-rays in general practice resolves itself into two parts:

(1) The diagnosis of disease or injury.

(2) The treatment of disease.

In diagnosis extensive use may be made of the X-ray examination, there being hardly any region of the body which at one time or another is not put to a searching examination for the detection of disease or injury. Diagnosis by visualisation leads to an appreciation of the extent of the disease or injury, and thus to a more thorough foreknowledge of the probable consequences of the lesion; therefore a valuable aid in prognosis is available. That the lesion has been demonstrated adds to the value of treatment in that the appropriate treatment can be applied with a certitude impossible if an accurate diagnosis is not made.

Further repeated examinations during the course of treatment are often of use in determining the progress made.

The treatment of disease will be specially dealt with later. (See Chapter IV., page 101.)

The Diagnosis of Disease and Injury

X-rays are of great use to the general practitioner in the diagnosis of disease and injury. In this work it will not be supposed that the practitioner himself has an installation and takes his own radiographs, but that he makes his own careful examination, draws his own deductions from the history and physical evidence, makes his diagnosis, and sends the patient to the radiographic expert for investigation and confirmation or otherwise of his diagnosis. To have a diagnosis confirmed is often of great value. To find that a condition feared is not supported by radiographic evidence is often of equal value, and to have a doubtful case, where the history and physical evidence may support one of two or more conditions, cleared up, and the diagnosis established, is often of the greatest value of all.

These cases are familiar to all and need not be dwelt on. To illustrate by simple examples, there is the demonstration of the existence or non-existence of a fracture after injury, or the presence or absence of a renal calculus. The existence of patches of tuberculous infiltration in the lungs of a patient, the presence of a pleural effusion in a patient who has pain in the side unaccompanied by a rise of temperature, or the demonstration of an empyema at a later stage of the illness—all these are familiar instances of the help afforded by X-rays in diagnosis.

The general practitioner who uses discrimination will soon appreciate the type of injury and disease in which radiographic examinations are of real value, and differentiate them from the cases when X-ray examinations are a waste of time and money and only serve to bring discredit on the method. Thus, to establish that a patient is suffering from cardiospasm and not from malignant stricture of the œsophagus is a point of the greatest importance in diagnosis and prognosis.

Again, in a patient suffering from malignant disease of the alimentary tract, the information obtained from a bismuth-meal examination and a radiographic examination of the thorax for the detection of secondary nodules there, is often the deciding factor to a surgeon as to whether or not to operate. Sometimes in cases of primary carcinoma of the breast, when it is found that the deep glands of the axilla and the mediastinal glands are involved, the surgeon decides against operation. The patient will then be dependent for relief of symptoms upon other forms of treatment. As will be pointed out later, X-rays and radium will be found to be among the most valuable palliative agents. Or again—in children—where the first suspicions are aroused as to the presence of hip-joint disease, the evidence of early and repeated radiograms is often of the greatest assistance in the matter of treatment.

It will therefore be obvious that the radiographic examination is of value in :

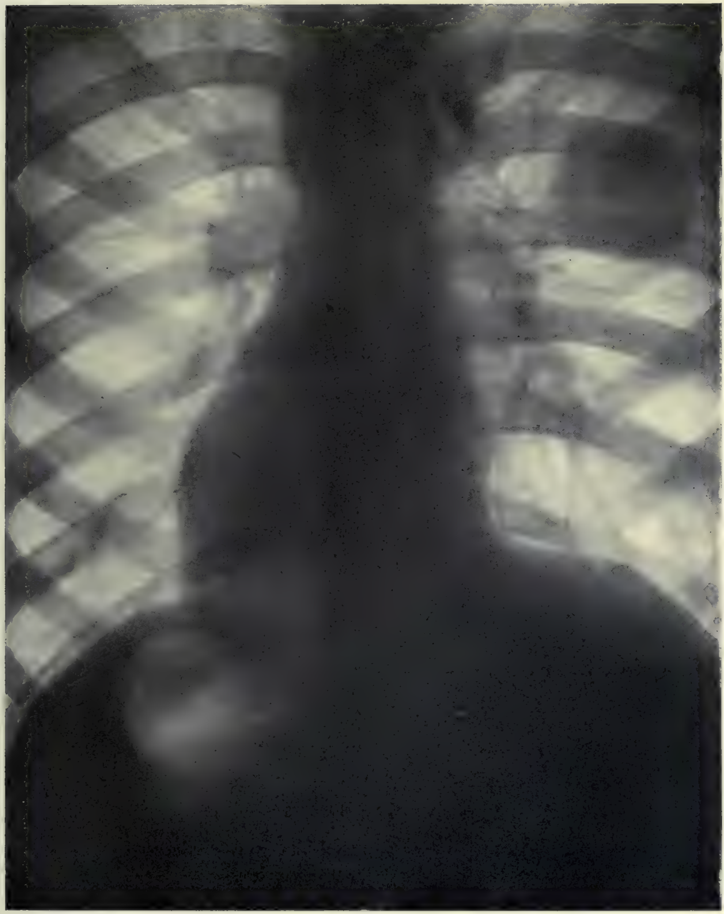
(1) Confirming the diagnosis already made by the practitioner.

(2) Determining the extent of a bone or joint injury.

(3) Establishing a differential diagnosis where the practitioner is in doubt regarding the actual condition present, in which the symptoms are such that one or more alternative diagnoses are possible, as, for example, between aneurism and mediastinal tumour or between Hodgkin's disease and sarcoma of the lung, etc.

(4) Defining the extent of disease, *e.g.* patches of tubercular disease involving the lungs, or the presence in the lungs of secondary nodules, often an important point in the prognosis of a case of malignant disease.

(5) Correcting an erroneous diagnosis. This



THORAX.

Showing secondary sarcoma of lung indicated by an area of consolidation at the right side. The seat of the primary disease was in the left tonsil.

is one of the most important functions of X-rays in diagnosis. A patient may present the appearance and symptoms of a very grave disease, yet on X-ray examination a much simpler condition may be found. The value of this evidence and the relief to the patient are very great.

(6) The Detection of Foreign Bodies. For the general practitioner the chief value of radiography in relation to foreign bodies lies in the ability to demonstrate the presence and the position of a foreign body. Amongst these the following—pins, safety-pins, nails, coins, buttons, hair-pins, pipe-stems, tooth-plates—have at one time or another been demonstrated in the trachea, bronchi, all parts of the alimentary tract, and in the genito-urinary passages. The majority of these foreign bodies have been accidentally swallowed, or drawn into the trachea, or inserted into the rectum or vagina and bladder by the patient. Such an accident always causes a good deal of alarm, and it is well to have the position of the body located so that its progress and after history may be watched. Foreign bodies in the bronchus may need immediate surgical attention. In the alimentary canal the majority pass safely through, but they may lie for days in the stomach.

In addition to locating the position of a foreign body, X-rays are sometimes of great help at the time of actual removal. The surgeon can be guided to the spot and may be able to see the body under the rays and grasp it. Thus a case occurred in which a baby of three months or so swallowed an open safety-pin brooch which lodged across the œsophagus. The baby was radiographed on two successive mornings and the pin had not moved down. The baby was then anæsthetised, and under X-rays the surgeon was able to see the pin, pass down a pair of forceps, and remove it without any damage to the soft parts.

Localisation.—The foreign body may be accurately located by special methods, the details of which need not be described here. The removal of a foreign body is facilitated by an accurate localisation.

These instances are quoted to illustrate the very wide field for the employment of X-rays, but it is not well, nor to the advantage of the practitioner, that he should rely implicitly on X-rays for a diagnosis, certainly not to the extent of the medical student who, when asked by an examiner how he would diagnose a pleural effusion, replied, " I would have an X-ray taken, sir."

There is a real danger that the practitioner, especially if recently qualified and fresh from a hospital where he has had ample opportunities of availing himself of the aid of X-rays, may tend to rely too implicitly on X-rays for establishing the diagnosis, and may neglect to carry out in all its minutiæ the examination of physical signs and the investigation of symptoms which enabled him to arrive at a diagnosis in the days when radiography was not. This leads to error in two ways :

(1) It tends to cultivate in the practitioner an inexactitude of observation and a slurring over of details which must be detrimental to his efficiency.

(2) It may hamper the radiographic examination, because information may be omitted on points that would guide the radiologist and direct attention to some particular organ or structure.

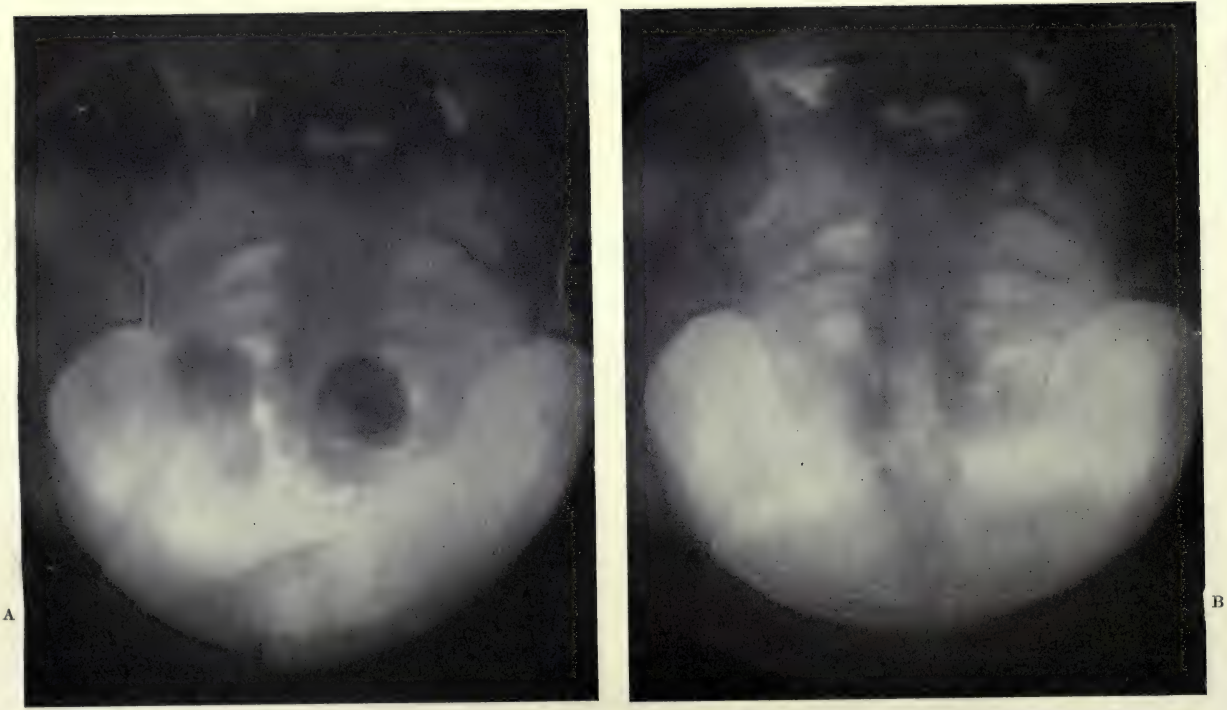
It is therefore important that the practitioner, before sending a patient for radiographic examination, should have satisfied himself by very careful investigation and study as to the probable cause of the symptoms complained of, and that he should furnish the radiologist with all the details he can of the patient's condition, in exactly the same manner as is done when a patient is sent to the consulting physician or surgeon. Concise details of the history enable the radiographer to determine the best way to examine the patient and may appreciably influence the establishment of a diagnosis.

The General Preparation of the Patient

This is a point of great practical importance and one with which all medical men should be thoroughly conversant, as in many cases the diagnostic value of the examination is affected by the lack of preparation of the patient, especially in abdominal work. For example, in such work, if the bowels are not thoroughly cleared, the plate obtained may be valueless on account of the conflicting shadows formed by bowel contents. These may obscure fine detail essential to establish the diagnosis. It is not at all uncommon for an appointment to be made and the patient present himself for the examination, only to find that the radiologist is unable to get a really satisfactory plate because the medical man sending the patient has omitted to instruct him to have the bowels thoroughly cleared out and regarding the kind of food he should eat previous to the examination. This necessitates a second examination, and the patient's confidence in his medical adviser may be seriously shaken by what he regards as a want of proper knowledge on his part.

The exact preparation for each class of examination will be dealt with in the appropriate section, but the broad outlines may be indicated here:

PLATE III.



SIMULATION OF STONE IN THE BLADDER.

A. This radiogram shows two definite shadows—one superimposed above the other; these could easily have been mistaken for stones in the bladder, but the faint shadow to the left of this caused suspicion that they might be due to bowel contents.

B. After free purgation this plate was taken. It will be seen that the shadows have disappeared, clearly indicating that they were not due to calculi.

(1) For the investigation of limbs and joints no general preparation is required. The clothing must be easily removable if desired, and opaque objects such as safety-pins, hooks, and buttons taken off. In the case of fractures better radiograms are obtained if splints are removed immediately prior to the radiographic examination. This is, however, not always possible. The practitioner should intimate whether this may be done or not, and it is best that he should attend at the examination for the purpose of readjusting the splints. The patient naturally has more confidence in his own medical man than in a stranger.

(2) In all cases of examination of the thorax the patient must be prepared to remove all clothes down to the waist. A thin woollen or cotton vest may be worn, but such articles of clothing as combinations and stays must be taken off.

(3) In cases of abdominal investigation the patient must always be instructed to take a purgative on the preceding day, and to take only a very light meal, such as a cup of tea and piece of toast, two or three hours previous to the examination. In particular cases it may be necessary to purge the patient for two or more days before the examination. For the investigation of the kidneys and bladder the final prepara-

tion should include an enema; this is particularly indicated in cases where it is necessary to pass an opaque catheter into the ureter for the purpose of injecting collargol to demonstrate radiographically the ureter and the pelvis of the kidney.

In gastro-intestinal examination it may be necessary to examine the bowel by injecting opaque material. The rectum and colon must therefore always be thoroughly emptied and cleansed by soap and water enemata.

At the examination the patient must be undressed, but a light vest and knickers may be worn, and a thin woollen dressing-gown without buttons. It is not necessary for the patient to be uncovered, but the clothing must be thin and uniform, easily folded back out of the way, and all fastenings removed. For this reason one-piece garments, such as combinations, are not suitable.

(4) Many persons about to be X-rayed for the first time are very nervous and apprehensive about the examination, not from a fear that the process will be painful, but from a general dread of the unknown, which causes a very undesirable condition of nervous tension. This may result in the patient trembling and shaking all over, and being unable to refrain from a cry and violent start when the current is turned on. Such nervousness may make it almost impossible

to get a good radiograph because the patient cannot keep quite still. It could be almost entirely prevented if the medical man in charge of the case explained the nature of the examination to the patient, dwelling on the fact that it is entirely painless and need cause no alarm, that when screening is necessary it must of necessity be carried out in an absolutely darkened room, and that the important point on which the patient should concentrate attention is the necessity of keeping perfectly still and steady while the exposure is made.

In illustration of this it may be pointed out that it is a not uncommon thing for a patient to be sent to a radiologist for examination of the œsophagus, and for nervous apprehension to be so marked as to cause inability to swallow the bismuth or barium paste or emulsion, thus presenting appearances suggestive of stricture. Re-examination at a later date, when the patient is accustomed to the procedure, reveals that the inability to swallow was caused by reflex nervous spasm and that no stricture exists.

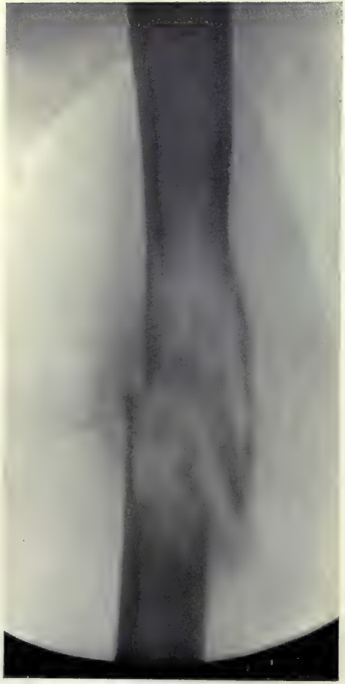
The Interpretation of Plates

The full interpretation of an X-ray plate demands much experience and is a matter of education. To the great majority of practitioners the information conveyed by variations of density in shadows and irregularities in outline, although plain to the eye of the experienced observer, is veiled in mystery. A gross lesion, such as a shattered joint or badly fractured limb, is easy to detect, but the correct interpretation of the shadows obtained in the course of a bismuth meal, and the deductions to be drawn from those shadows, is a very different matter and requires great experience. The full interpretation will not be attempted in a book of this kind, but the broad general principles will be dealt with, because now that radiography is being employed so largely in the diagnosis of diseased conditions, as well as of injuries, it is important that the practitioner should have a working knowledge of the art of interpretation, and thus be able to enter into the details pointed out by the radiologist, and from his knowledge of the patient and the clinical symptoms be able to corroborate or negative the pathological conditions indicated by the radiogram.

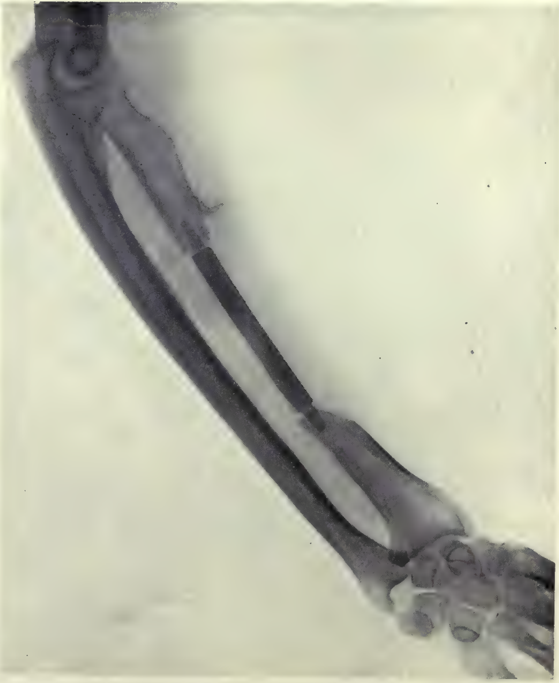
Definition of Terms.—The developed X-ray plate is a negative, and the term is used in the same sense in ordinary photography. The print obtained on silver bromide or gas-light paper is a positive.

The X-ray plate or a print from it is referred to as a "radiogram." The term "radiograph,"

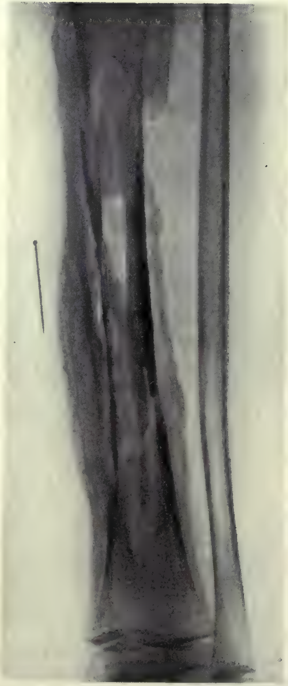
PLATE IV.



Secondary carcinoma in shaft of humerus, showing "spontaneous fracture." The primary lesion was in the breast.



Gunshot injury of shaft of radius where damaged bone has been removed and a bone graft introduced.



Extensive osteomyelitis of tibia, showing sequestrum and new bone formation.

so frequently used, is wrongly applied. The term "radiogram" is unfortunate also, since a message transmitted by wireless is also called a "radiogram."

Definition of a Radiogram.—A radiogram may be defined as a shadow-picture of structures lying in different planes reproduced on a flat surface. (Stereoscopic pictures show the different planes very well.) It is not a photograph, although the positives have to be printed on paper.

When reading an X-ray plate it is well to remember that the structures looked at are viewed through the skin and soft parts. It is best to read from an illuminated negative which reproduces to some extent the actual conditions. The negatives should be placed in a suitable viewing box for the purpose.

When examining a radiogram, and in this instance we assume that it is a negative, it should be remembered that in taking a plate the film side is always placed next the patient; therefore when viewing, if the film side is gazed upon by the reader, the structures portrayed are viewed in the same relation to each other as that in which they actually are in the patient. The X-rays pass from the target of the X-ray tube through the body of the patient, and make an impression upon the silver of the sensitive emulsion, which is converted into a negative picture in the process of development, the eye of the observer being in the same position as the X-ray tube, the tube being above the object.

When the object is X-rayed from the opposite point of view, *i.e.* with the tube beneath or behind the object, the reverse condition is obtained.

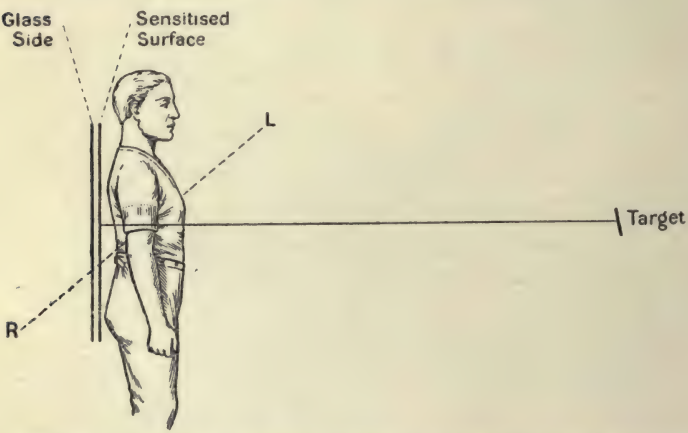


Fig. 1.—Diagram to explain the path of X-rays through an object to the sensitive emulsion of a plate. (Tube in front of the patient.)

The terms "right" and "left" are used in relation to the patient, not the observer.

In screen operations the fluorescent screen takes the place of the plate. The observer then sees through the patient, and the parts are in their proper position in regard to right—that is of the patient.

But it must also be remembered that the X-ray tube is frequently placed behind the patient, with the plate in front of him, so that when the film side of the negative is gazed on by the observer the sides are reversed, the right side of the film portraying the structures lying at the left side of the patient. If the observer looks through the glass side of the negative this reversal of side is avoided. These points do not

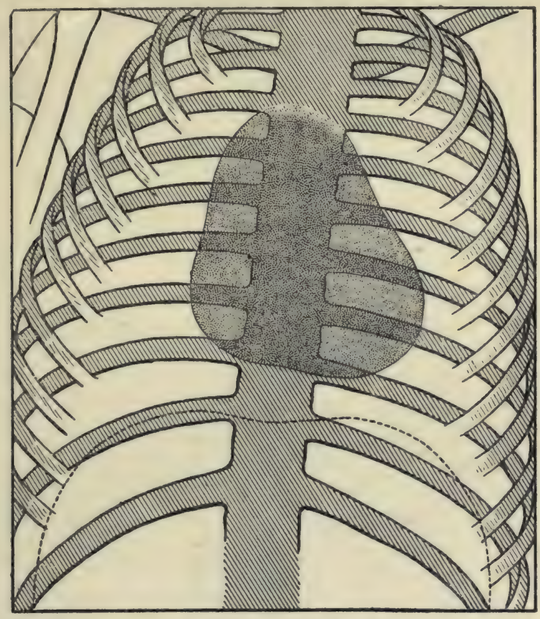


Fig. 2.—View of thorax seen on the fluorescent screen (with tube behind the patient).

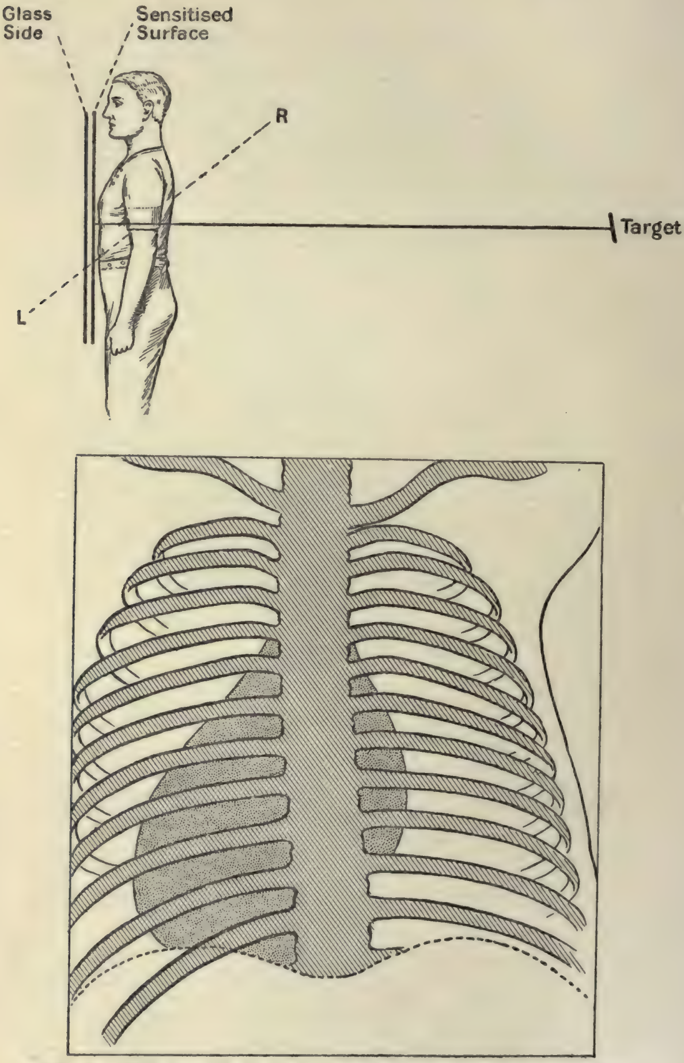
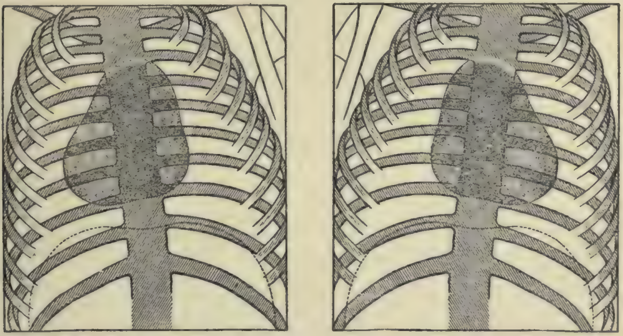


FIG. 3.—The picture of thorax seen in the negative when the tube is behind, and the plate on the chest of the patient.

occur in viewing a print from this negative. The print is the positive, and the parts are then seen as they lie in the patient.

The positive or print reverses the position, since in printing the sensitive side of the paper is placed in close apposition with the film side of the negative, thus :



Position of parts seen in the negative (looking at film side).

Position of parts seen in a print from the negative.

Fig. 4.—Examples of negative and positive pictures.

The Essentials of Interpretation.—The observer should be able to distinguish the bony framework and the soft parts in relation to the bones, and the details of the bony structure. It is essential that the practitioner should be familiar with the appearances of the normal skeleton and organs, and it is therefore advisable that a good set of normal radiograms should be studied. To meet this need as far as possible a number of normal radiograms are included in the full-page illustrations, but for a complete set reference must be made to larger works.

In order to assist the reader to properly appreciate the pictures obtained by radiography, the description of radiograms of bones and joints will be dealt with first, as being simpler than those of the chest and abdomen.

Radiograms of bones and joints are generally taken to show injury or disease. The earliest indications of disease are difficult to detect. The first essential is a familiarity with the normal appearance of bones and joints. Good radiograms are very important for correct interpretation. This greatly facilitates the recognition of the abnormal. For instance, where the normal dense appearance of bone structure is familiar, a condition of rarefaction due to absorption or rheumatoid arthritis is easily recognised.

The Essentials of a Good Radiogram.—(1) There must be no indication of movement, however slight, on the part of the patient during the exposure. Movement is apt to cause blurring of fine detail and double outlines.

(2) The radiograms of each part of the body should be taken in a standard position with a carefully centred tube, so as to minimise distortion, which is often misleading, particularly in the estimation of the displacement in fractures, etc.

(3) If the exposure is correctly estimated and the plate carefully developed, the radiogram should show not only the outline of the bone but shadows of the surrounding soft parts.

The bone should be shown not merely in outline, but with details of structure. In joints the inter-articular spaces should be sharply defined and also the contour of the bones entering into the joint. In young bones the epiphyseal lines should be clearly defined.

These points relate more especially to the negative or plate, but often the general practitioner is sent a print for inspection. The print being positive shows dark surfaces where the plate shows light. Thus dense structures show as dark shadows. With due care in exposure and development, the print can be turned out so as to show nearly as much detail as the negative.

In the interpretation of radiograms of bones and joints the grosser lesions, such as fractures with marked displacement, are easy to recognise, but fine fractures without displacement are very difficult.

The examination of bones and joints is extensively employed for the detection of departures from the normal indicative of disease. In the earliest stages of disease the changes may be very slight and yet be very significant, thus :

(1) A slight irregularity and thickening of

the periosteum may indicate a localised periostitis or a commencing malignant or tubercular process.

(2) Slight irregularity of the epiphyseal line may indicate early tubercle or the first manifestations of an extensive osteomyelitis.

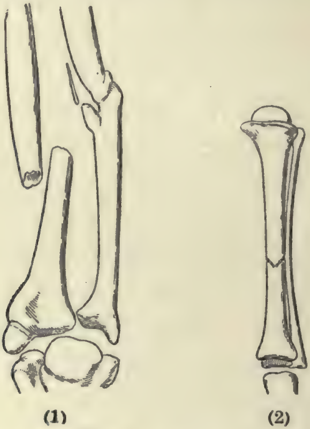
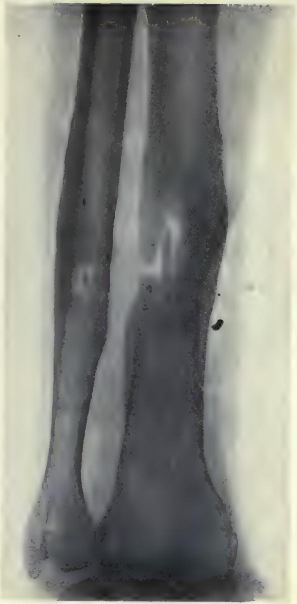


FIG. 5.—Diagrams illustrating—(1) Fracture through shafts of radius and ulna, with lateral displacement; (2) Transverse fracture of tibia and fibula with no displacement.

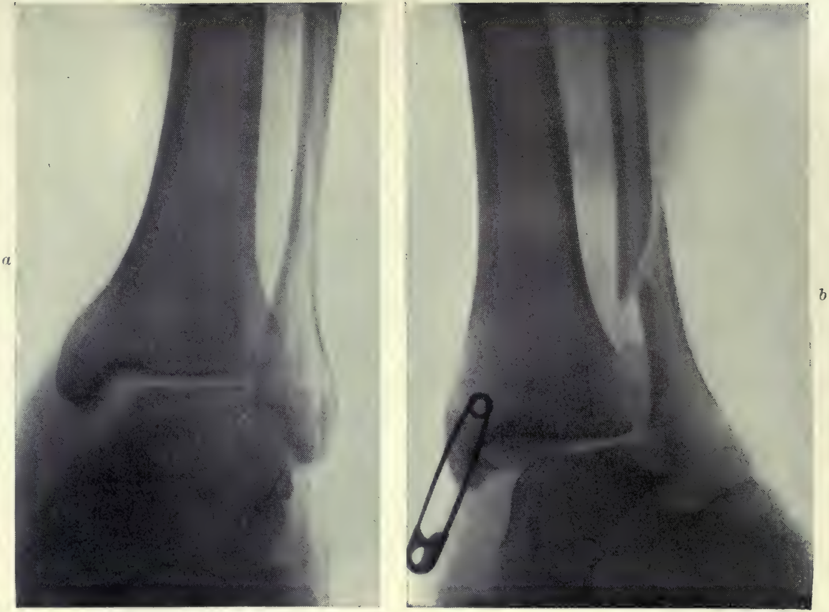
(3) Thickening of the shaft may occur as a result of healed fracture with callus formation round the fracture, abscess or gumma, or new growth.

When disease of a joint is suspected a radiogram should be taken, and this should be compared with one of the corresponding joint on the



OLD INJURY TO RADIUS AND ULNA.

Showing sequestra (War injury).



FRACTURE OF THE FIBULA. (From the Seamen's Hospital, Greenwich.)

a. Antero-posterior view, in which no injury can be detected. *b.* Position obtained by everting the foot, when a well-marked fracture of the lower end of the fibula was revealed.

other side. The radiogram of the suspected joint should be carefully surveyed as to:

(1) The relative position of the bones compared with a normal.

(2) The clearness of the inter-articular space. The depth of this is to some extent dependent on the position assumed when the radiograph was taken. For instance, in the knee-joint, if the joint is flexed, the inter-articular space is lessened, and if extended, increased. If the joint has been radiographed in the correct position, that is, fully extended, a narrowing of the inter-articular space is considered to be indicative of disease of the cartilage with absorption. Conversely, extensive disease of the synovial membrane with effusion into the joint leads to a widening of the inter-articular space. In such cases the shadow thrown by the soft parts is much increased in all diameters and should be clearly defined.

(3) Areas of absorption occurring in the bones entering into a joint. These may indicate a rarefying osteitis, or abscess, or tuberculous disease.

Screening is employed in all, or nearly all, examinations for the detection of injury or disease, but for the recognition of fine detail such as is found in the early stages of bone disease, or in injuries where there is practically no displacement, plates should be taken.

The recognition of variations from the normal is possible by either method, so that the appearances observed on the screen and on the negative are the same, except in one particular, namely that the parts shown as light shadows in the negative are seen as dark shadows on the fluorescent screen.

In the following descriptions of radiograms of the normal parts the description may be taken to refer to the actual condition seen, irrespective of whether a positive or negative picture is being viewed.

Bearing these points in mind, it is easy to proceed to a consideration of the interpretation of radiograms of regions of the body where more difficulties present themselves, and where the practitioner will find himself at a loss unless he has considerable experience.

THE INTERPRETATION OF RADIOGRAMS OF THE THORAX

Radiography of the thorax may be considered under two heads :

(1) Screening operations—Radioscopy.

(2) Production of plates—Radiography.

These are of equal importance, because points may be observed when both are used which might be missed if only one or the other is employed.

In all interpretation of chest radiograms, as in bone work, the first essential is a thorough acquaintance with the appearances presented by the normal plate. When these have been mastered the recognition of the abnormal is more easy.

1. **Screening.**—The interpretation of screen appearances is difficult, but certain definite landmarks can be indicated. These are:

(1) The shadow of the heart can be seen pulsating, somewhat to the left of the middle line.

(2) The rise and fall of the diaphragm in respiration can be detected and the evenness or otherwise of the movement noted.

(3) The roots of the lungs and the aorta can be identified, also the chest walls and the movements of the ribs. It should be remembered that the appearances seen on the screen are positive and as they occur in the patient.

When screening, the necessity for an absolutely dark room must be impressed upon the observer, and also the fact that it is necessary to remain for several minutes in a darkened room in order to render the retinæ more sensitive to the appearance on the fluorescent screen.

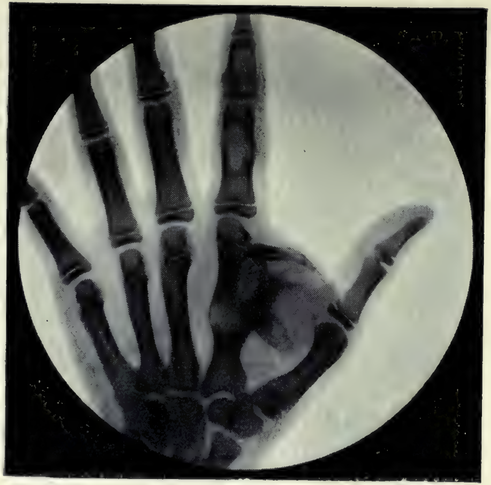
(4) The sternum is lost in the central shadow,

but the spine can be clearly seen when a penetrating ray is used. The ribs are well seen on the lateral aspects of the picture. They rise and fall with the respiratory movements.

2. **Radiography.**—This consists of the exposure of the photographic plate to the rays passing through the object to be examined. The plate is developed and a negative is obtained which is a permanent record of the conditions present.

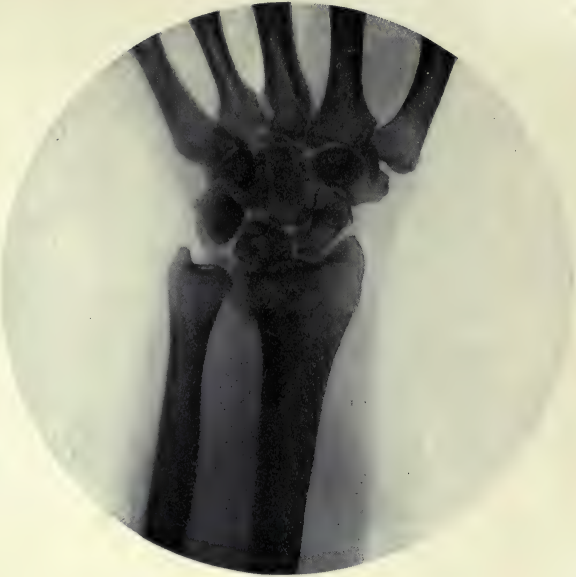
Plate Interpretation.—The appearances seen on the plate are negative, the plate portraying the photographic record of the screening, save that the parts are reversed in density. It must be realised, however, that the plate only represents one phase of what is seen in screening, and that the sharpness of the detail depends on the shortness of the exposure.

The Routine Examination of a Negative of the Thorax.—As the plate is a flat surface the effect of depth can only be got by stereoscopic pictures, but an impression of the depth can be appreciated by the size of the shadows. The bony framework of the chest is well seen, both anterior and posterior portions of the ribs being well defined. If the radiogram is taken with the plate on the back of the patient and the tube in front, the bony structures nearest to the plate, *i.e.* the scapula, spine,



ENCHONDROMATA OF BONES OF HAND.

The metacarpal bone of the index finger is extensively involved by an expanding growth which is in parts ossified. The first and second phalanges show an earlier stage of the same condition, characterised by rarefaction of the area involved, which has not yet begun to expand. The second phalanx on its ulnar side shows a bud-like projection at the proximal end of the rarefied area.



COLLES FRACTURE.

Showing injury to the lower end of radius.

and ribs, are sharp and distinct, while the anterior portions of the ribs, being farther away, are distorted and enlarged and less distinct, seeming to recede from view.

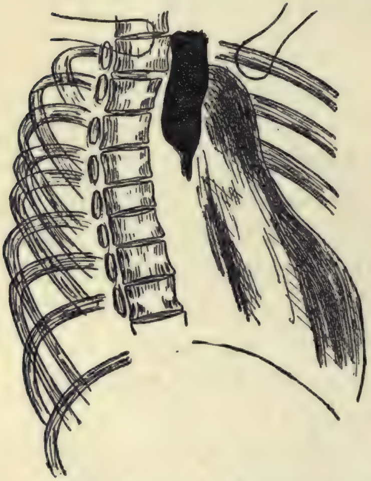
The Heart Shadow is seen in the middle line, bulging to the left, the aorta and large blood-vessels showing at the upper part of the heart shadow (see Plate II).

The Roots of the Lungs appear at each side of the heart shadow as irregular branching structures gradually fading into the lung substance, which, in a good negative, can be detected as a faint mottling between and behind the ribs.

The Diaphragm can be seen inferiorly as a dense white structure rising higher on the right side than on the left. On the left side of the diaphragm shadow on the abdominal aspect an opaque area can sometimes be seen, varying in size and shape. This is a collection of gas in the stomach. Occasionally when the colon is distended by gas, this may also be seen to the left of the stomach. The shadows, as described above, are seen in a negative taken with the plate on the posterior aspect of the body with the tube in front and viewed from behind (the glass side).

When the plate is in front and the tube behind, the appearances vary somewhat from the above description. The heart shadow is smaller and the anterior ribs relatively smaller and sharper.

In connection with the aorta, it must be remembered that there is a distinct bulge at the aortic arch, which must not be mistaken for an aneurism. Accurate centring of the tube is important in relation to this bulge, as a slight obliquity of the body may lead to distortion of the bulge and the simulation of an aneurism.



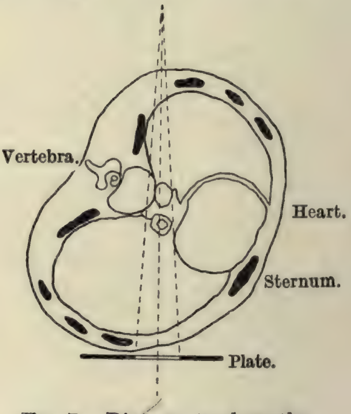


FIG. 7.—Diagram to show the position for lateral oblique examination of the thorax.

FIG. 6.—Diagram illustrating the appearance seen in a semi-lateral view of the thorax. Opaque food in the upper part; at the lower border of the shadow the tapering end indicates a stricture.

Radiograms of the chest are often taken not only in the antero-posterior and postero-anterior positions, but also in the lateral and oblique positions. In the oblique position there is a clear space between the heart shadow and the spine. In this clear space lies the œsophagus, and therefore in examinations for disease of the aorta and œsophagus this view is often presented.

Variations from the Normal in Disease.

(1) *Heart and Mediastinum.*—Changes are seen in the size, shape, and outline of the normal shadows, which indicate the presence of disease. Thus there are characteristic cardiac shadows associated with definite heart lesions. Various types of shadow are recognised as indicative of cardiac or pericardial disease. Hydroperi-

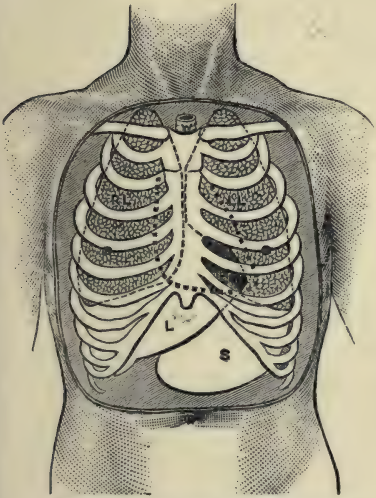


Fig. 8.—Anatomical appearance of the thorax.

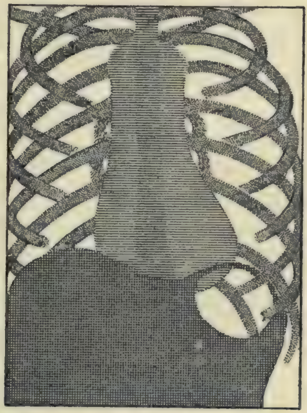


Fig. 9.—Radiographic appearance of the thorax.

cardium, for example, gives a very definite and distinctive outline. Intracardiac lesions also lead to changes in the mediastinal shadow. For instance, enlargement of the normal mediastinal shadow may indicate the presence of a mediastinal tumour, of enlarged glands, of aneurism of the aorta, or of secondary growths. Primary growths are occasionally met with.

(2) *The Lungs, Pleura, and Bronchi.*—(*a*) Patches of increased density scattered throughout the lung may indicate tuberculosis, or new growth or actinomycosis; (*b*) patches of calcification, especially at the apices, may indicate healed tuberculosis; (*c*) thickening of the peribronchial shadows may indicate general fibrosis, tubercular or otherwise; (*d*) localised areas of dense shadow may indicate collections of fluid, pus, or serum; (*e*) irregular patches of shadow at the roots may indicate enlarged bronchial glands, caseous, fibrosed, or calcified. Calcification of glands usually indicates healed tubercle or other chronic disease. Thick fibrous tissue obscuring the lung detail and penetrating between the lobes indicates thickened pleura.

A small, very dense shadow at the root of the lung surrounded by a clear area extending to the chest wall, with an absence of lung detail around it, indicates a complete pneumo-thorax. The same appearance with a fluid level below indicates a pyo-pneumo thorax. A dense shadow extending from the root of the lung to the chest wall, with an absence of all detail, indicates a large collection of fluid.

The Diaphragm is a dome-shaped structure situated between the thorax and the abdomen. Radiographically it cannot be distinguished from the combined shadow formed by the shadows of the diaphragm, stomach, and liver on the abdominal side, while on the thoracic side it blends with the shadows of the pleura and bases of the lungs. Therefore alterations in the shape, size, and position may occur from the normal, due to lesions in any of the structures which enter into the formation of the diaphragm shadow.

It is therefore very important that the appearance of the normal shadow should be familiar. The normal movement is a rise and fall corresponding to the movements of the chest walls and lungs in respiration.

The dome on the right side is normally at a higher level than on the left, the amplitude of movement varying in different individuals with the degree of expansion of the chest.

In the normal condition the movement is free and even, any alteration being indicative of a lesion either in the lungs or pleura, or in the structures situated below it. Limitation of movement is suggestive of early tubercle or inflammatory lesion, and when such limitation is present without a definite lesion the whole chest should be carefully scrutinised for indications of disease. Irregular movement on either side is indicative of pleural adhesions or pleuro-pericardial adhesions.

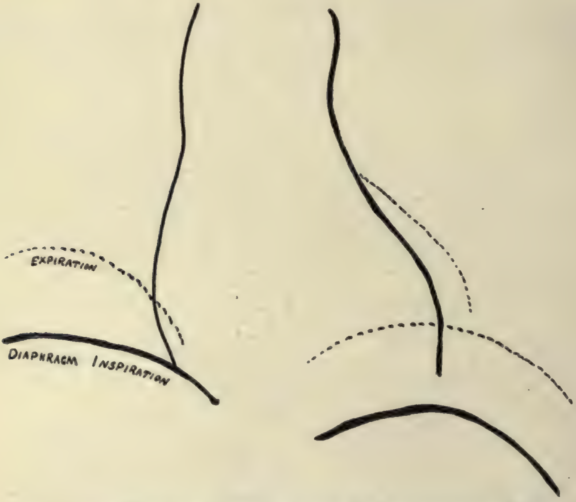


Fig. 10.—Diagram showing extent of movement of the diaphragm in respiration.

An obscuration of the clear outline of the diaphragm, with opacity above on one or other side, is indicative of a simple or purulent effusion. Elevation of the upper surface of the diaphragm with increased density may indicate a subphrenic abscess, and in this relationship a gas formation may occur, indicated by a clearer shadow defining the under surface of the diaphragm. When the pleura is unaffected, the lung substance is distinctly seen above this shadow. A sub-phrenic abscess is generally associated with a small pleural effusion.

The diaphragm may be pushed up by an enlargement of the liver, and this may be due to abscess, growth, passive congestion, or hydatid cysts. Other abdominal lesions may also cause displacement of the liver with elevation of the diaphragm.

THE EXAMINATION OF THE ABDOMINAL VISCERA

Screening.—A preliminary screening examination should be carried out in all abdominal radiography to note the position of the structures, and the position and behaviour of the diaphragm. The liver shadow can be definitely seen, and the stomach is indicated by a collection of gas at the fundus. The small intestine is indicated by collections of gas, and the colon can often be identified in its entirety when distended with gas. The lower dorsal and lumbar spines can be differentiated, and the kidney shadow can occasionally be seen. Lower down, the bony structures of the pelvis can be distinguished.

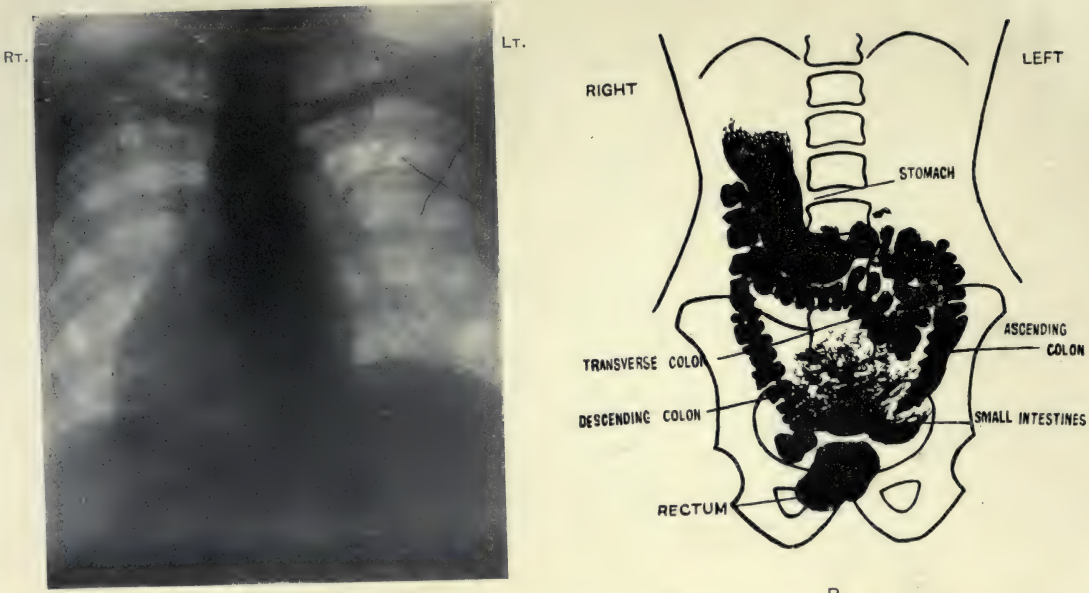
The screen examination of the abdomen is useful in a general survey, but when it is necessary to elucidate obscure points in gastro-intestinal diagnosis it is customary to give the patient a meal containing an opaque substance. This when situated inside the alimentary canal will give a shadow of the organ in which it is contained. Salts of barium and bismuth are generally used—the carbonate or oxychloride of bismuth or the sulphate of barium. If the last-named salt is used it must be pure, and the best obtainable, as impurities may give rise to poisoning. The sulphide must on no account be used, as this salt is highly toxic, and poisoning has occurred when, by accident, it has been used instead of the pure sulphate.

For the examination of the stomach and intestine 3-4 oz. of the sulphate of barium are mixed with a vehicle consisting of bread and milk-cornflour or sour milk.

The meal is generally given when the patient is fasting, and observations are made while the stomach is filling, and at intervals until the whole meal has been evacuated. Very valuable observations can be made upon the condition of the intestinal tract which are of great service in diagnosis.

The Examination of the Alimentary Tract by the aid of the Opaque Meal.—Screen examination

PLATE VII.



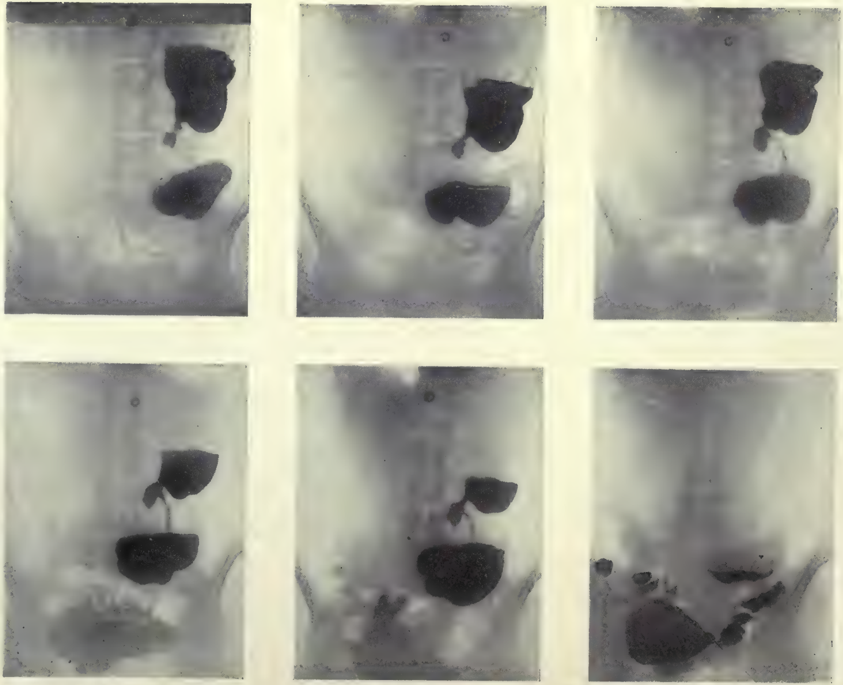
A

B

COMPLETE TRANSPOSITION OF VISCERA.

On screen examination the apex of heart was found to be on the right side; an investigation of the history of the patient revealed the fact that he had been operated upon for appendicitis and the appendix was found at the left side. The patient was given an opaque meal in order to ascertain the position of the stomach and colon. Fig. B is a composite tracing from a series of plates taken during the examination.

PLATE VIII.



$\frac{1}{4}$ hour. 1 hour. 3 hours.

5 hours. 7 hours. 24 hours.

OPAQUE FOOD IN STOMACH.
(HOUR-GLASS CONTRACTION.)

Penetrating ulcer on lesser curvature of stomach.

of the behaviour of a stomach when filled with bismuth food, and while this is passing into the duodenum, is of great value in diagnosis, some observers preferring to make their observations from screening alone, while others rely on plates. The combined method is perhaps the best.

Immediately after completion of a meal the stomach is seen outlined and full of food. The food lies at the lower part of the stomach, the cardiac end being occupied by a collection of gas, which shows as a clear space. Between the two is an indefinite area, consisting of fluid stomach contents. In the lower pole of the stomach, where the bismuth food lies, the peristaltic waves can be seen passing to the pylorus.

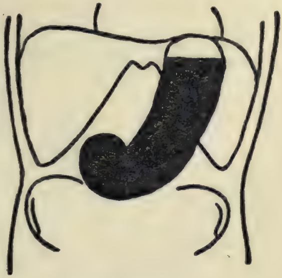


FIG. 11.—Diagram of normal stomach, fully distended with opaque meal.

The stomach is divided radiographically into the fundus at the top (this generally contains a quantity of gas, which shows on the plate as a regular dark area), the corpus or body, and the antrum leading to the pylorus. The pylorus cannot be differentiated radiographically, but its position may be indicated by the appearance of definite constrictions in the outline during peristalsis. These constrictions appear at regular intervals as the peristaltic wave propels the food into the duodenum. The first part of the duodenum is indicated by a definite shadow known

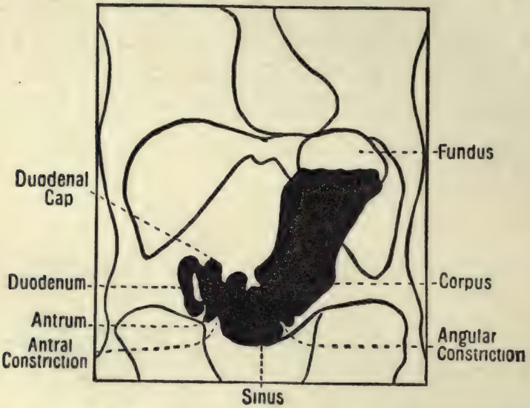


FIG. 12.—Radiographical divisions of the stomach.

as the duodenal cap. Deformities of this shadow are important in diagnosis as they generally indicate the presence of an ulcer or adhesions.

Departures from the Normal indicative of disease:

(1) Greatly increased size of the stomach with marked delay in emptying indicates dilatation and possibly pyloric stenosis.

(2) A greatly elongated organ without much dilatation is indicative of gastroptosis.

(3) A small stomach with a narrowing of the bismuth shadow and a persisting jagged irregularity of outline in one or more places is

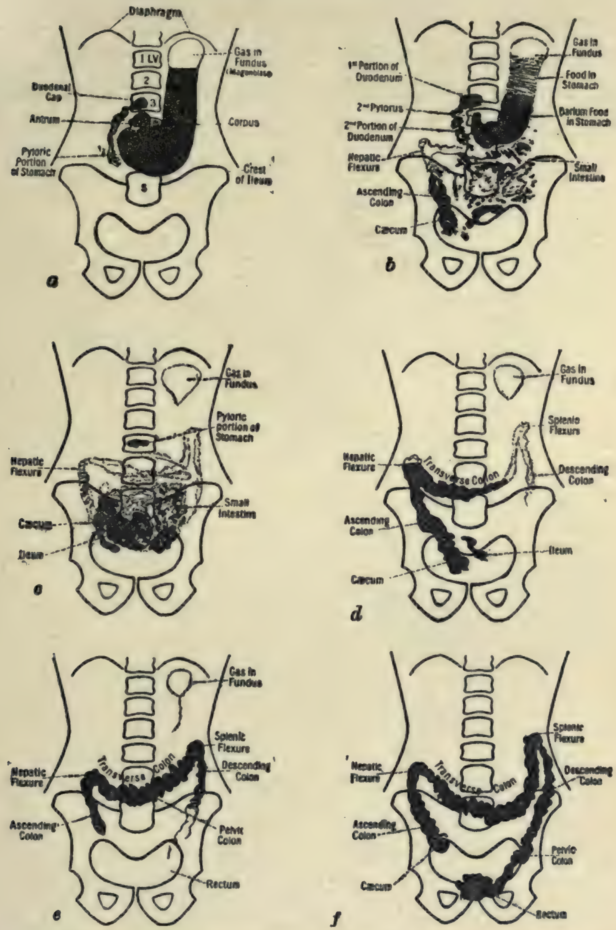
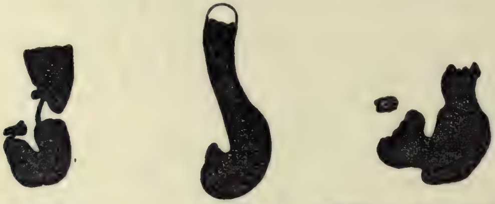


FIG. 13.—Diagrams showing opaque meal in stomach, duodenum, small and large intestine.

(*a*) Stomach immediately after ingestion of meal.
(*b*) Two hours after meal taken.
(*c*) Four hours after.
(*d*) Six hours after.
(*e*) Twenty-four hours after.
(*f*) Forty-eight hours later.

indicative of growth or indurated chronic ulcer with inflammatory thickening.

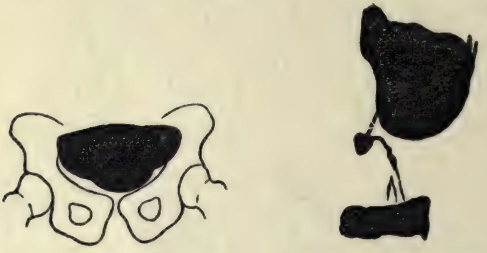
(4) Hour-glass contraction needs no special description. It may be functional or organic, due to chronic ulcer or malignant disease.



Hour-glass stomach.

Atonic stomach.

Evidence of pyloric stenosis caused by carcinoma at pyloric end of stomach.



Stomach fully distended in pelvis.

Hour-glass stomach showing penetrating ulcer in lesser curvature.

Fig. 14.—Types of abnormal stomach.

(5) A narrow streak of bismuth food passing through into the duodenum, with marked delay in emptying, is indicative of pyloric stenosis whether due to ulcer, spasm, or growth.

The Opaque Meal in the Small Intestine.

The Duodenum.—The passage of the bismuth meal is, normally, very rapid, and a departure from this is indicative of a lesion somewhere. Persistent deformity of the duodenal cap supports this. The principal lesion of this structure is duodenal ulcer, but it may be implicated in lesions of the surrounding structures such as the gall-bladder and pancreas. Persistent irregularity of the bismuth outline may be seen. Sometimes when a too rapid emptying of the stomach and duodenum is observed, and the appearances are suggestive of a duodenal ulcer, the condition is found to depend on a reflex irritation from lesions elsewhere. This is especially likely to occur in chronic inflammatory conditions of the appendix and cæcum. The two conditions may be coexistent. The jejunal and ilial shadows of bismuth meal may be altered very considerably by extensive peritoneal adhesions due to extensive tubercular or malignant disease.

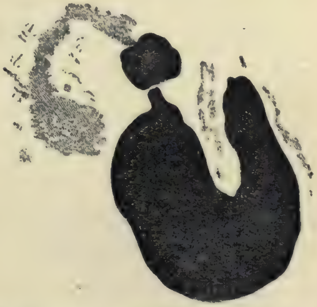


FIG. 15. — Diagram of food in stomach and duodenum, showing deformity of shadow suggestive of duodenal ulcer.

The Ileum is frequently examined for evidences of stasis. The chief radiographic evidence of this condition is marked delay in the passage of the food through the ilio-cæcal valve. For normal rate of progress see Fig. 13.

The Colon.—Normally the opaque meal should reach the cæcum in 6-8 hours and the rectum in 24 hours.

The principal departures from normal conditions of the colon demonstrated radiographically are: (1) Alterations in position—visceroptosis; (2) great delay in the passage of the meal due to adhesions; (3) the presence of malignant growths.

The cæcum and appendix call for special technique. The matter is dealt with in differential diagnosis, as is also the gall-bladder and other special areas.

The complete comprehension of the opaque meal examination will be aided—it is hoped—by a study of the diagrams in the text, and of a number of typical radiograms.

It will be readily understood how elaborate the technique for this examination has become when it is stated that in the ordinary routine examination special attention must be paid to the following regions, and when the matter of differential diagnosis has to be considered it will easily be perceived how numerous are the conditions requiring special consideration. Already men are specialising in gastro-intestinal diagnosis alone, so important has this method become.

The regions requiring individual attention are:

(1) The region of the œsophagus.

(2) The region of the stomach.

(3) The region of the duodenum.

(4) The region of the gall-bladder, bile-ducts, and liver.

(5) The region of the cæcum and appendix.

(6) The region of the colon and rectum.

After a complete general survey of the entire tract has been made, the departures from the normal may indicate a lesion of one or other of these regions. It may be necessary to repeat the examination for a definite diagnosis, using the special technique for the suspected area, and by screen observations and the production of negatives produce evidence of the lesion.

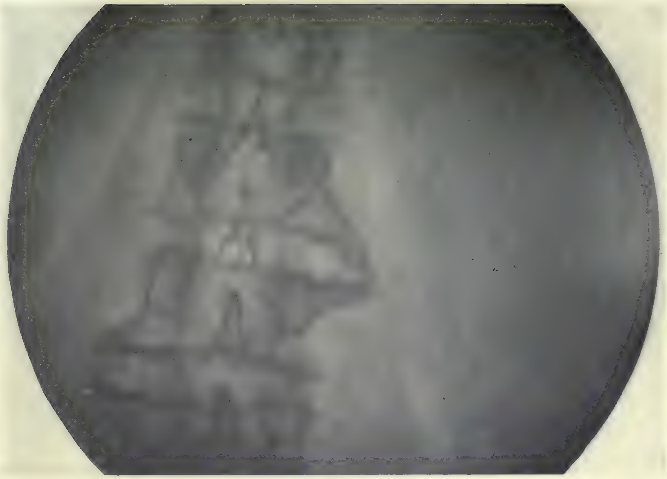
This is known as the "Direct Method," and is greatly in favour in the American school.

Interpretation of Radiograms of the Kidney.—The accurate interpretation of kidney radiograms is frequently difficult. A normal radiogram should include the following parts: the last two ribs, the last dorsal vertebra, and the upper three lumbar vertebræ with their transverse processes. By the side of the spine the shadow of the psoas muscle should be clearly seen. The kidney shadow should be seen in a good radiogram. Large calculi may be demonstrated without the outline of the kidney being identified, yet the presence of patches of different density occurring in the kidney outline is suggestive of disease, and, therefore, unless the outline of the kidney can be identified disease cannot be excluded. The kidney shadow on the right side is less easily demonstrated than on the left side, owing to the presence of the liver and gall-bladder, which often obscure the outline of the upper part of the kidney.

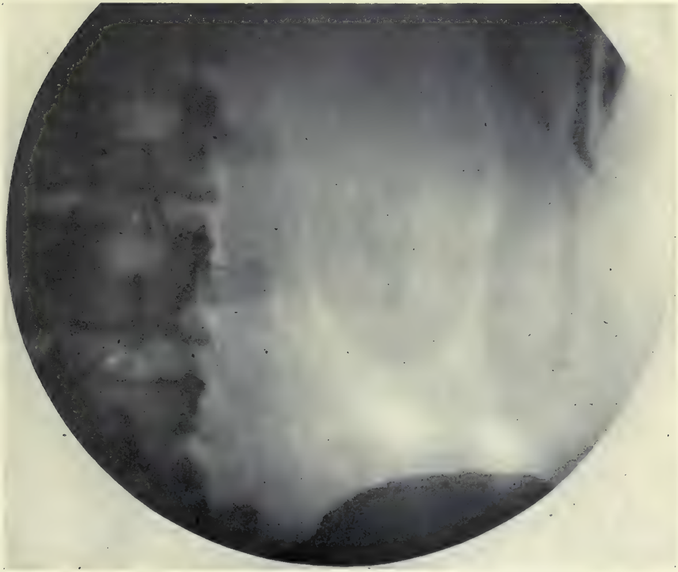
Departures from the Normal.—A greatly enlarged kidney shadow is indicative of hydronephrosis or growth. Small patches of great density occurring in the kidney shadow are suggestive of calculi. These vary in density according to the chemical composition of the stone. A small dense shadow situated in the track of the ureter indicates a stone in the ureter in any part of its course.

This has to be distinguished from other shadows which may be found in the same region. These, when present, raise points in differential diagnosis of great interest, and often of extreme difficulty.

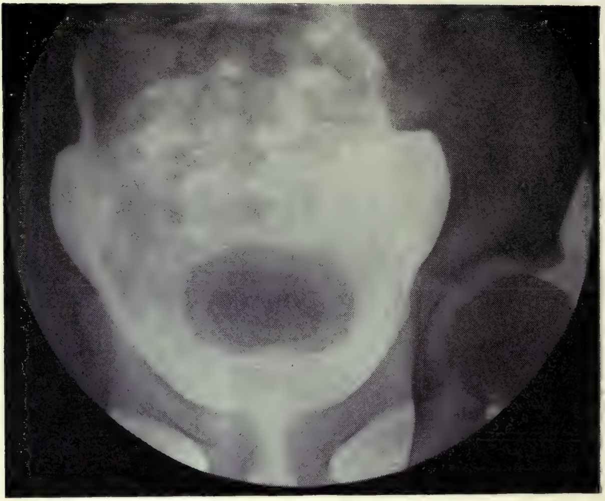
Radiograms of the Pelvis.—The bony framework of the true pelvis is shown, including the sacrum, coccyx, and the whole of the pubic arch. The outline of the bladder may occasionally be shown when distended, and may be



SPONDYLITIS DEFORMANS OF LUMBAR SPINE.

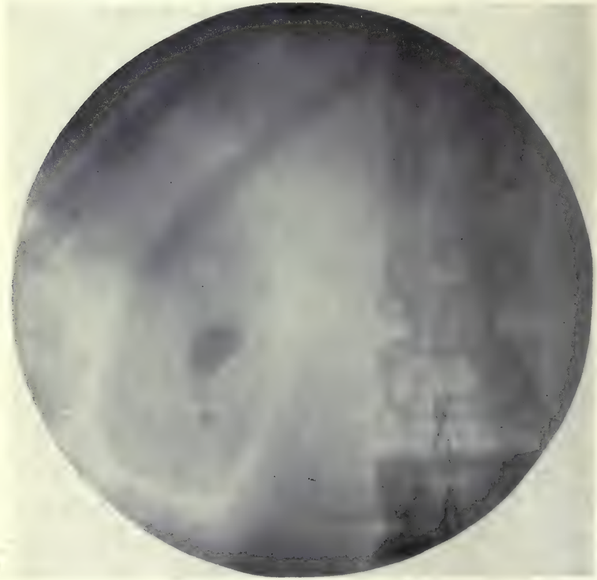


NORMAL KIDNEY REGION.
Showing outline of kidney.



LARGE STONE IN THE BLADDER.

The variations in the density of the stone are well shown.



CALCULI IN LEFT KIDNEY.

The outline of the kidney is clearly shown.

The patient had been operated upon a year before and no stone found; at the operation it was noted that the capsule was thickened.

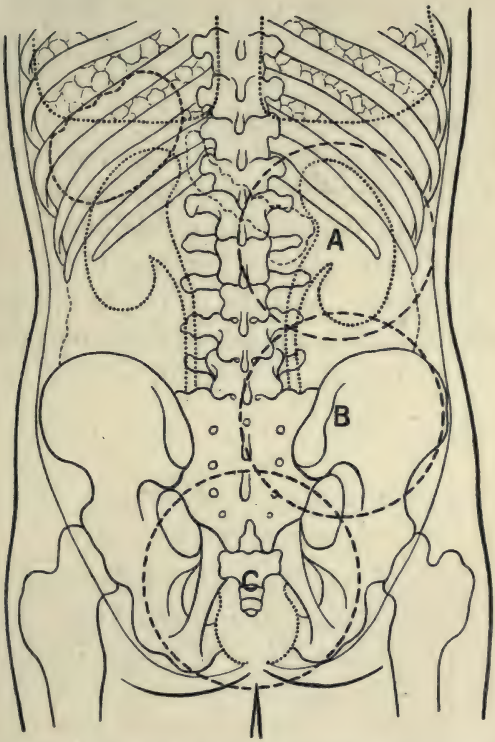


FIG. 16.—Diagram of the abdomen, illustrating the areas required for a complete examination of the urinary tract. On the right side A, B and C represent three circular areas which include the kidney, the whole of the right ureter, and the bladder . but for a complete examination two other areas similar to A and B, but on the left side, should be included.

clearly defined when a solution of collargol or barium has been used. This may also be used to define the ureters and pelvis of the kidney.

Departures from the Normal.—Vesical calculi are easily demonstrated, being indicated by shadows of varying size and density. The structure of a calculus may sometimes be shown in a good radiogram. Foreign bodies introduced into the bladder may be identified. Ulcerations and growths may be occasionally demonstrated if deposits of salts happen to form on them.

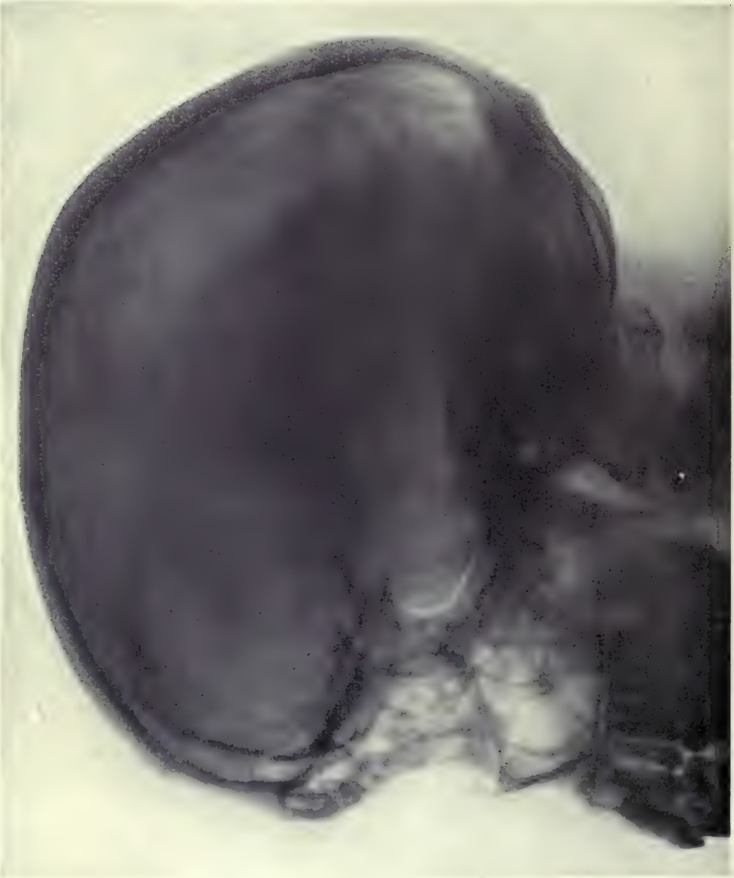
INTERPRETATION OF RADIOGRAMS OF THE HEAD AND NECK

Apart from the diagnosis of fracture of the bones, the special regions of the head and neck require special techniques to demonstrate them to the best advantage.

The details of these techniques are too elaborate to describe in this work, but the following regions can be well shown :

(*a*) The orbits ; (*b*) the accessory sinuses, *i.e.* the maxillary, frontal, ethmoidal, and sphenoidal sinuses, antra of Highmore ; (*c*) the Sella Turcica ; (*d*) the structure of the internal ear ; (*e*) the structure of the mastoid cells ; (*f*)

PLATE XI.



LATERAL VIEW OF SKULL.

Showing greatly enlarged sella tursica due to the presence of a pituitary tumour.

the structure of the upper and lower jaws and teeth; (*g*) the interior of the skull.

The possibilities of help in obscure conditions involving these regions are very great, but skilful technique and an extensive knowledge of interpretation are necessary before accurate conclusions can be drawn from an examination of the radiograms.

DANGERS ATTENDANT ON AN X-RAY EXAMINATION

When X-ray examinations and treatment are carried out under proper conditions by an experienced radiologist, the dangers which the patient undergoes from the actual proceedings are usually slight. Attention must, however, be drawn to the following point:

Patients sent for examination in a greatly enfeebled condition from general causes are liable in the X-ray consulting room to the same dangers from sudden collapse, syncope, etc., as they would be in any other consulting room. Patients in enfeebled health should not be sent to a consulting room for an elaborate opaque-meal examination, but be examined in bed in a nursing home. They may collapse from the strain. Patients suffering from gastric ulcer may, at the time of examination, have an attack of hæmorrhage, and this may occur quite independently of the examination. Great care is necessary with such patients. The tendency to syncope may perhaps be a little intensified by the atmosphere, heavily charged with electricity, peculiar to the room where X-rays are constantly being generated.

Apart from this danger, which is dependent on the condition of the patient and not upon the X-ray treatment or examination, the dangers incurred may be classified under three heads :

(1) The immediate constitutional effects of treatment.

(2) Effects of over-exposure.

(3) Late effects of treatment.

(1) **The Immediate Effects of Treatment.**—These are specially likely to occur in patients undergoing treatment when the exposures are rather prolonged, as in fibroid disease, or prophylactic treatment for malignant conditions.

Treatment is accompanied by a feeling of languor and exhaustion, sometimes amounting to faintness. Sometimes there is nausea amounting to sickness for a day or two afterwards, sometimes headache, and often a certain amount of nervous tension and giddiness. The apprehension of the unknown is partly accountable for these symptoms, which yield to a little sal volatile and a whiff of smelling salts at the time, and rest after treatment. Patients should always be advised to rest for a day or two after prolonged treatment and to lie up and take things very quietly.

(2) **Effects of Over-exposure.**—These may come on within twenty-four hours, or in two or three weeks, and may be local or general in manifestation. The general symptoms, where dosage has been very heavy, are intense prostration with rapid pulse, raised temperature, and feelings of malaise. The temperature has been known to rise to 103-104° and the patient be really ill. The treatment consists of rest in bed, with careful attention to diet and medicinal treatment appropriate to the symptoms. As a rule the patient develops tolerance of treatment and subsequent reactions are not so severe.

Local Manifestations.—These consist of skin reactions and may be present in every degree, from slight reddening to actual burning of the skin, with blistering and subsequent ulceration. The treatment is as for burns of the skin. These occurrences should be considered as counter-indications for continued treatment, and time allowed to elapse before that area is again treated. In X-ray examinations of regions covered by hair, care should be taken not to give an over-exposure. In the radiography of the auxiliary sinuses, for example, alopecia may follow upon over-exposure.

On this account the practitioner, when sending a skull case for examination, should inquire whether the head has been recently X-rayed. It is usual in the examination of head cases to insert an aluminium filter between the tube and the area irradiated.

(3) **Late Manifestations** may come on weeks, months, or even years after treatment, and vary according to the nature of the case and the degree of reaction. Thus complete alopecia may follow the treatment of ringworm, and dry skin the treatment of hyperidrosis. Chronic dermatitis merging into ulceration may follow prophylactic over-radiation of one area only. Any marked skin reaction is likely to be followed at a later date by telangiectasis.

Permanent sterility may follow treatment for menorrhagia or dysmenorrhea.

CHAPTER II

X-RAYS IN DIAGNOSIS

The previous sections have dealt with the general subject of X-rays in diagnosis, being concerned with the appearances of normal radiograms and the chief features presented by them. Technique has only been touched upon when necessary to facilitate description and comprehension.

The whole subject of X-rays in diagnosis is so extensive that only a brief survey of a few of the most prominent features met with will be possible. The chief object will be to indicate in what forms of disease X-rays are likely to be of use. To deal fully with any one section would be impossible; the more difficult regions will therefore be described, the technique being entered into when required to clearly indicate in what manner the rays are utilised to aid diagnosis.

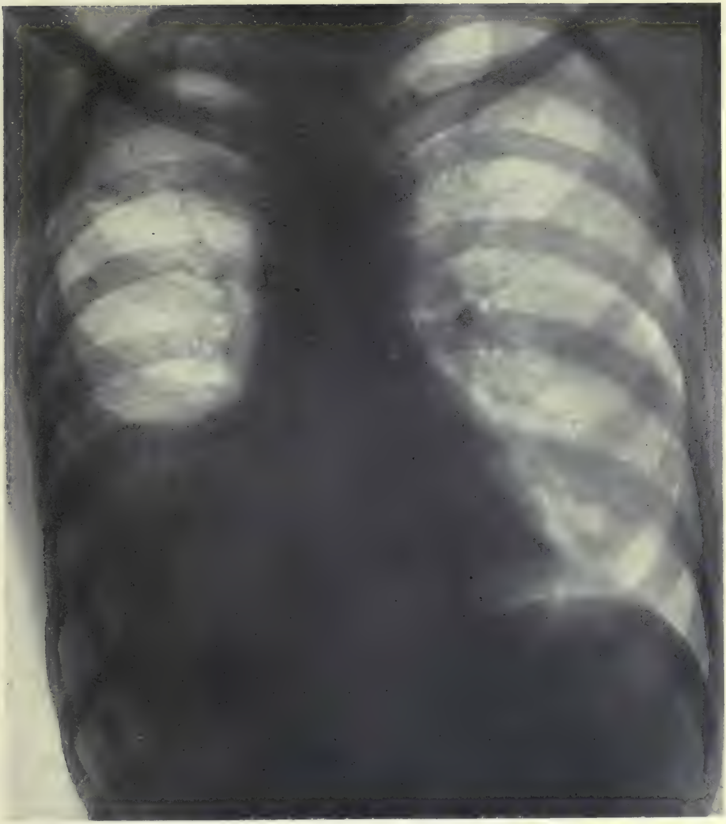
Where diagrams and radiograms are given, the description beneath each figure will be made as complete as possible, so as to enable the reader to grasp the essential points without having to refer to the text.

A. DISEASES OF THE CHEST

No special preparation in the way of drugs or diet is required, but the patient must be prepared to remove all clothes to the waist, with the exception of a thin woollen vest. An adult is usually examined standing in the erect position, first by the screen and then by plates. In a number of cases it may be wise to vary the procedure. The patient can be radiographed in the prone or sitting position. As it is important that there should be no jerk or sharp movement which may spoil the sharpness of the radiograph, he should be warned that after he has been placed in the correct position any movement on his part during the exposure will spoil the plate.

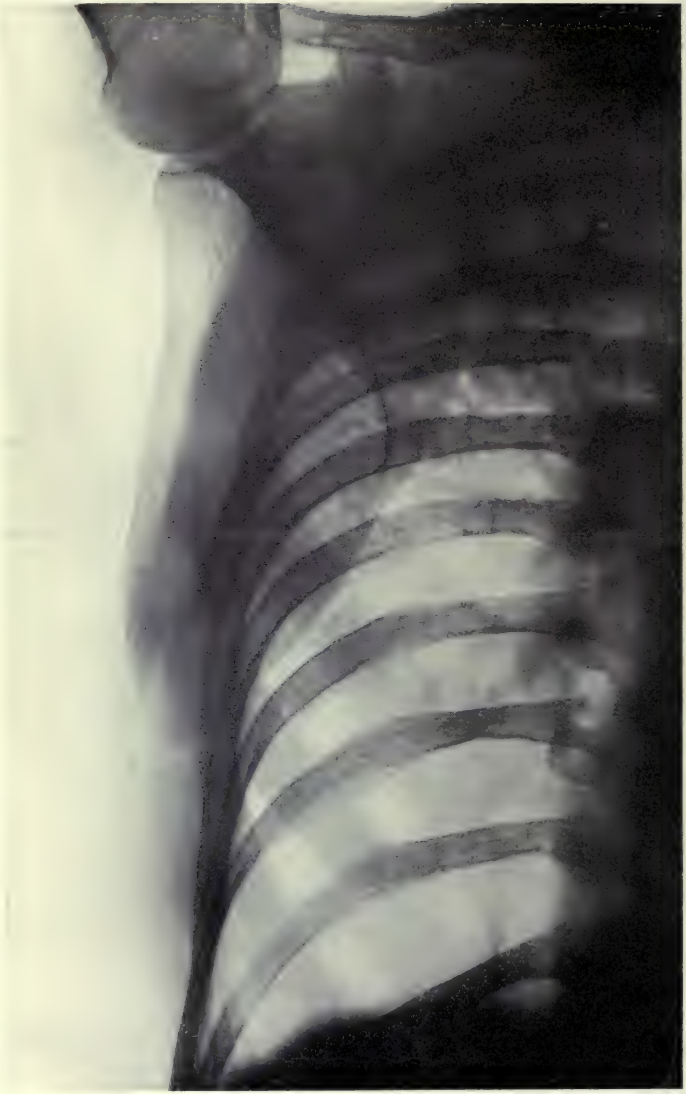
Tubercle.—X-rays are frequently of great service to the practitioner in cases of tubercular disease of the lungs, or where this is suspected. They are of use:

(1) In early diagnosis when clinical signs are still indefinite. All practitioners are familiar with the patient who has slight pyrexia, cough,



CHRONIC PLEURAL EFFUSION.

The radiogram shows on the right side (left of picture) the characteristic appearances of this condition when examined in the upright condition.



ABSCESS IN AXILLARY BORDER OF SCAPULA.

Indicated by oval clear area near the lower end. This is probably tuberculous, and the diagnosis is supported by the irregular opacity at the apex of the lung, which points to a primary tuberculous lesion there.

sweating, loss of flesh and expectoration, with a negative report on the sputum. X-ray examination of the chest is useful in these cases for demonstrating the presence or absence of tuberculous disease.

The question of at how early a stage X-rays will enable the observer to detect the presence of tubercular disease of the lungs is an important one. In the minds of a number of practitioners the value of the method depends upon the answer to this question.

X-rays are, after all, only another method of inspection, and the value must always depend upon the experience of the observer in recognising early departures from the normal in the screen examinations and in the negatives. When a first-class plate is obtained, very early changes may be appreciated, and, in screening, variations in the movements of the diaphragm, and other changes, may give the clue to the presence of disease. Such X-ray evidence, when considered together with the early physical signs, the history, and the result of bacteriological and other tests, may add the final weight which turns the scale to the diagnosis of tubercle.

In other cases the existence of an unsuspected old focus of disease may be revealed, or a larger lesion than that indicated by percussion and auscultation may be demonstrated.

The radiologist who ventures to diagnose very early tubercle from the X-ray evidence alone courts disaster.

(2) In determining the extent of the disease, the involvement of one or other or both lungs, the type of disease, and the presence of complications such as pleurisy or pleural adhesions. The question as to whether both lungs are involved, before gross lesions are manifest, is often a very important one in the matter of prognosis, as is also the type of disease, whether likely to be accompanied by much fibrosis or breaking down of lung tissue. Bands of fibrosis and adhesions, the signs of old mischief, can be detected, also the free or impeded movements of the diaphragm, and the presence of caseating glands. These are points where the radiographic expert can give much assistance to the general practitioner, and often indicate the lines along which treatment will best help.

(3) In detecting, by repeated observations, any improvement or the reverse in the condition. For example: a patient, a child of eight, had an attack of pneumonia. Convalescence was delayed by a tendency to slight pyrexia in the evenings and slight cough. X-rays revealed the presence of a small quantity of clear fluid shut in between the diaphragm and the chest wall. A second radiograph, taken after an

interval of several weeks, showed that this fluid had been absorbed.

Pleurisy.—The diagnosis of pleurisy is usually established without the aid of radiography, though this is often of service in detecting the extent of mischief and the presence of bands of adhesions. Moreover, small collections of fluid shut in by adhesions are occasionally revealed. The presence of fluid is shown on the plate by a dense shadow in an abnormal position, accompanied by a pushing down of the diaphragm on the affected side, and on screen examination the impaired movement of the diaphragm in respiration can often be noticed. Sometimes, however, cases occur when the symptoms usually associated with pleurisy, *e.g.* pain and pressure, are present, but where there is no clinical evidence to localise the mischief. In these cases X-ray examination may demonstrate a mediastinal, diaphragmatic, or interlobar pleurisy, or a condition of chronic mediastinitis.

Pyothorax (Empyema).—The radiographic appearances resemble those found in simple effusion, but the shadow is denser and the fluid tends more to be shut in by inflammatory adhesions. Moreover, the cup-like depression often observed at the top level of the fluid in a simple effusion is often absent or modified in appearance, owing to the fluid being thicker and denser.

Pyo-pneumo Thorax.—This condition can be demonstrated radiologically, and a characteristic picture be obtained. An opaque area at the lower limit of the thorax indicates the presence of pus, a clear area above it indicates air in the pleura, and a dense shadow towards the root of the lung indicates the collapsed lung.

Hæmothorax.—This is not a condition very commonly met with in practice, unless following an accident, or occurring as a complication in tuberculosis. During the war it was frequently seen as the result of gunshot injuries of the chest. The condition is attended by much collapse of the lung with absent or deficient respiratory movements, and can usually be diagnosed from the history and clinical signs.

The radiographic appearances are similar to those of pyothorax or other collection of fluid. There is opacity of a lung area, associated with a high and immobile diaphragm and with retraction of the mediastinal shadow towards the opacity. When the left lung is affected there is a marked increase in the area of cardiac pulsation, due to the retraction of the lung from the anterior surface of the pericardium. The lung opacity may develop on the same side as the injury or on the opposite side. The heart is frequently displaced.

The differential diagnosis between aneurism, malignant growth, and enlarged glands often presents some difficulty, as similar symptoms may occur in all three conditions.

In these cases a radiographic examination is often of value and may be of the greatest assistance in clearing up the diagnosis. In a work of this size the complete differential diagnosis, whether medical or radiographic, cannot be attempted, but attention may be drawn to the characteristic appearance in each of these three conditions. This will demonstrate in a few words the real value of a radiograph.

(*a*) **Aneurism.**—The normal outline of the heart and aorta is distorted. A dense shadow, which may be pulsating, obscures the normal outline of the aorta, while the heart lies in a horizontal position, somewhat displaced to the left, instead of in the usual semi-upright position. The displacement is in part due to actual muscle hypertrophy of the heart, due to the circulatory difficulties caused by the presence of the aneurism.

(*b*) **Malignant Growth.**—Only mediastinal growths are likely to cause diagnostic difficulty. The most usual are endotheliomata, lymphadenomata and lympho-sarcomata.

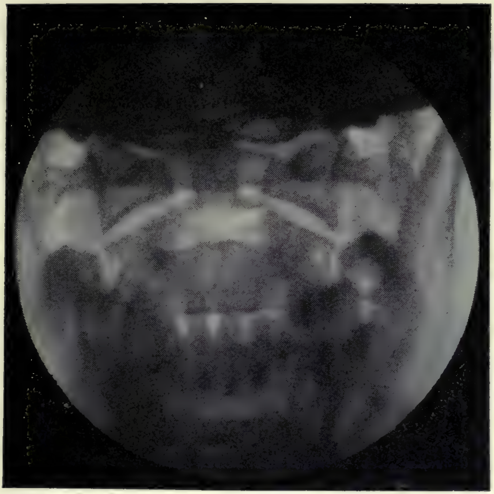
(1) *Endotheliomata* are slow growing and tend to be more or less encapsuled. They thus present a very dense shadow in the mediastinum,

which has a fairly well-defined edge and a smooth and rounded outline. The shadow fills the mediastinum, there is no pulsation, and the heart outline is much obscured, but may be detected in the lower part occupying its normal position.

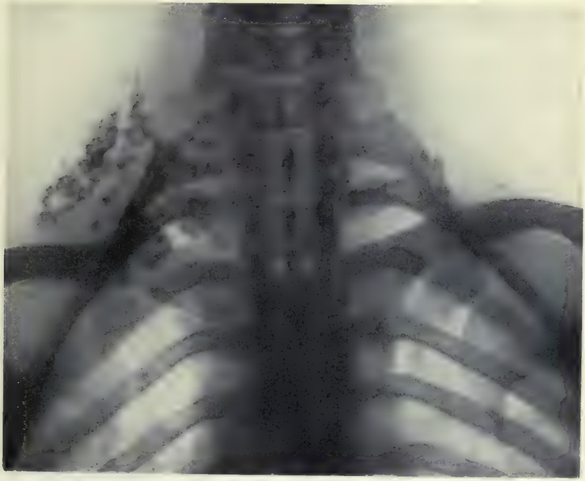
(2) *Lymphadenoma.*—Position and density of shadow the same as in endotheliomata, but the outline is more irregular and less smooth. The heart is not displaced to the same extent.

(3) *Lympho-sarcomata.*—The general appearances are the same, but in this form of growth there is a tendency to invade the lung tissue at the roots of the lungs, lympho-sarcoma being of more rapid growth.

(*c*) **Enlarged Lymphatic Glands.**—These may in extreme cases fill up the mediastinum with a dense mass, generally localised to one or other root of the lung, though both may be involved, but tending to break down before acute pressure symptoms arise, thus causing an abscess either in the mediastinum or opening into a bronchus. Enlarged tuberculous glands are frequently found at the roots of the lungs and even along the larger bronchi. They do not, as a rule, reach such a large size as glands affected in lymphadenoma and sarcoma, and therefore do not often give rise to such acute pressure symptoms, though if an enlarged tuberculous gland presses



FRACTURE OF BASE OF ODONTOID PROCESS.
Radiogram obtained by use of extension tube centred over the mouth.



CALCAREOUS DEGENERATION OF GLANDS IN CERVICAL REGION.

upon a bronchus it may cause characteristic symptoms. These glands may become caseous and break down, forming a localised abscess which may drain into a bronchus or into the mediastinum, forming a mediastinal abscess.

Two other conditions must be noted—œsophageal obstruction and hydro-pericardium. Œsophageal obstruction will be fully dealt with in the section on alimentary conditions.

Hydro-pericardium.—This may be diagnosed from aneurism and growth by the characteristic shape of the mediastinal shadow. The heart outline may sometimes be detected through the clear fluid.

Acute Inflammatory Conditions.—The help of X-rays is not very frequently required in the diagnosis of acute inflammatory diseases of the chest, but occasionally a radiogram is of assistance. In the case of an unresolved pneumonia, for example, the question may be decided as to whether tubercle is present, or a large empyema, or a small collection of pus shut away by adhesions. Again, in an obstinate case of bronchitis the diagnosis of simple or tubercular bronchitis or broncho-pneumonia can sometimes be settled.

Thickening of the pleura due to old pleurisy can also be demonstrated by X-rays, and this agent is often helpful in estimating the after effects of a severe pleurisy. X-rays also demonstrate very clearly the changes in the lung resulting from fibroid phthisis, and information of this kind may materially affect a prognosis.

Moreover, it is possible that X-ray treatment may be of use in such cases. The effects of the action of X-rays upon keloid scars has been so forcibly demonstrated in connection with war work during the past years that the question presents itself whether the fibroid tissue in the lungs could not also be influenced by radium or X-rays in order to alleviate to some extent the symptom of distressed breathing which sometimes occurs in cases of fibroid phthisis.

Diseases of the Heart and Aorta

Already fairly extensive use has been made of X-rays in the diagnosis of cardiac lesions, and as technique is perfected and elaborated there is little doubt that still greater advantage will be taken of radiography.

If special technique is employed it is possible to accurately measure the size and position of the heart and the character of the cardiac movements. The orthodiagraph is an apparatus used for this purpose. At a distance of two metres between the anticathode of the tube and the plate, distortion is practically eliminated.

By the aid of this apparatus various types of heart associated with particular lesions of the valves can be recognised.

B. Diseases of the Alimentary Tract

Preparation of the Patient.—When an X-ray examination of any part of the alimentary tract has to be made, the preparation of the patient is of the greatest importance. It is essential that the general practitioner should grasp this fully, and also the fact that the examination of the alimentary canal is a much more lengthy and elaborate affair than the taking of a radiogram of a bone or limb. Plenty of time is required, as series of plates must be taken at stated intervals, and often several plates at a time before a satisfactory one is obtained. In the course of a complete examination the patient will certainly have to make several visits during the first day, and probably visits on three successive days.

The practitioner should be fully aware of this, and should accordingly arrange with the radiologist when making the appointment, and the patient should be instructed to subordinate other arrangements to the examination, and to remain within easy distance of the consulting room, at any rate on the first day of the examination. For patients coming from a distance, by far the most satisfactory arrangement is to spend the first twenty-four hours or longer in a nursing home.

Clothing.—As stated before, the patient must be prepared to partially undress during the exposures, all garments with buttons, hooks, etc., being removed. A loose vest and knickers and a light dressing-gown may be worn.

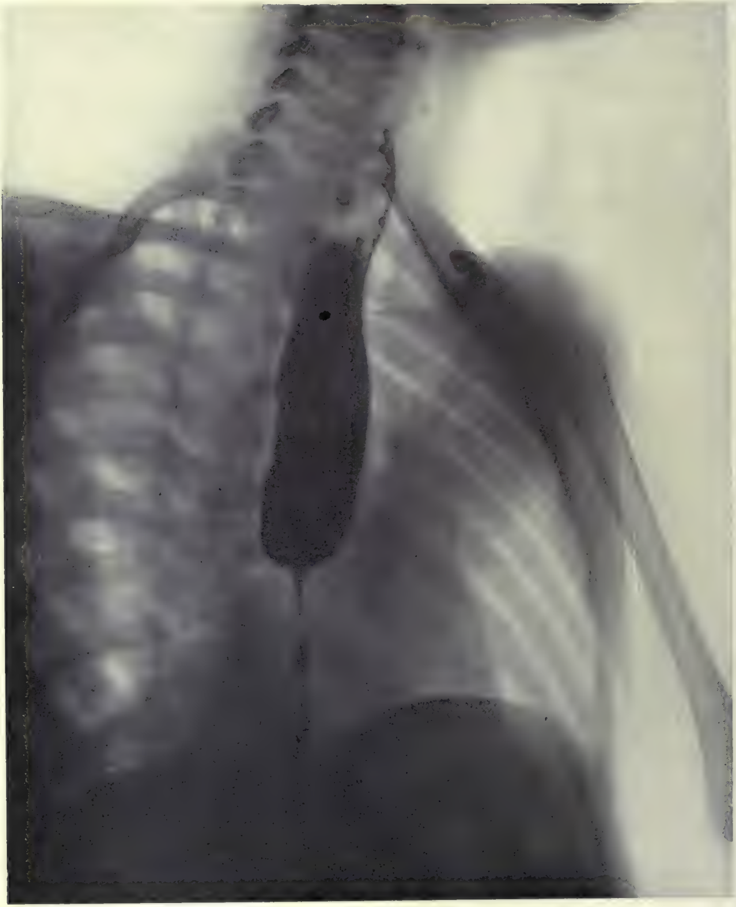
Food.—The stomach should be empty when the patient arrives for the examination. This applies to the general examination. Some operators prefer to give the opaque food as part of an ordinary meal. No food should have been taken except a very light meal, such as a cup of tea or bovril and a biscuit, three hours previously.

Aperients.—This is a very important part of the preparation of the patient. In a number of cases unless the intestine has been thoroughly evacuated good radiograms cannot be obtained. The best method of securing this is to give a good aperient two nights before the examination and a mild one the night before, to be followed by an enema on the morning of the examination.

THE ROUTINE EXAMINATION OF THE ALIMENTARY TRACT

The examination resolves itself into an investigation of the œsophagus, the stomach, the

PLATE XV.



NARROW STRICTURE OF THE LOWER THIRD OF THE ŒSOPHAGUS.

With dilatation above the stricture. Opaque food in dilated portion and in the stricture.

small intestine, the appendix, the gall-bladder, and the large intestine.

The Examination of the Œsophagus. — The bismuth or opaque substance examination of the œsophagus is of value in cases where the symptoms point to malignant disease or to stricture, and where the differential diagnosis between organic stricture due to cicatricial contraction following ulcer or malignant disease, and functional stricture due to spasm, is a matter of difficulty.

The presence of an œsophageal or pharyngeal pouch is often detected by X-rays, as is also pressure on the œsophagus due to aneurism of the aorta or enlarged glands in the mediastinum.

The establishment of the diagnosis in cardiospasm by the bismuth meal can usually be done by repeated examinations, and this has been the means of preventing useless operative measures.

X-ray examination is also of great value in detecting the presence and position of foreign bodies and the presence of congenital abnormalities. No special preparation is required in these cases. Bismuth or barium is given in the form of an emulsion or thin paste, and the act of deglutition is watched on the screen. Plates are taken when the passage of the bismuth is delayed or obstructed, in order to have a permanent impression of what is observed on the fluorescent screen.

The Examination of the Stomach. — The opaque meal examination of the stomach is carried out either as a part of a complete investigation of the alimentary canal, or as a separate examination. In all examinations of the gastro-intestinal canal the technique consists of (*a*) screening the part and (*b*) making radiographs. The patient should be prepared as for a complete investigation, in case this should prove to be desirable from an inspection of the plates taken of the stomach.

The patient is screened while taking the meal, and plates are then taken at stated intervals. These observations are often of great value. The points to which special attention is paid are :

(1) The size, shape, and position in the abdomen of the stomach.

(2) The behaviour of the stomach when filled with the bismuth meal, its movements, rate and mode of emptying, any irregularity of outline indicating ulcer or growth, any deformity, *i.e.* penetrating ulcer on the lesser curvature (see Fig. 14, p. 44).

(3) The length of time any bismuth remains in the stomach. X-ray examination is of great value in establishing a diagnosis of gastric ulcer and in differentiating between this and malignant

disease, also in the detection of dilatation and gastroptosis. In the latter condition part of the stomach may be demonstrated actually in the pelvis.

Gastric Ulcer.—This pathological condition can be detected by X-rays either in the active state as a simple, callous, or penetrating ulcer, or, in the later stages, when cicatricial contraction, due to fibrosis round the seat of the ulcer, and possibly hour-glass stomach may have developed. X-ray examination can not only detect the presence of an ulcer, but also indicate the extent to which the muscle wall is involved; this may be very important from the point of view of prognosis and treatment.

It is possible to differentiate between hour-glass contraction due to cicatricial changes, following ulcer or malignant disease, and that due to neurosis, *i.e.* spasm. This is often of great service and may be the means of preventing a useless operation. The examination may have to be repeated more than once, and a normal stomach picture may be obtained on one occasion and hour-glass contraction on another.

Malignant Disease.—In malignant disease of the stomach, after all the usual methods of examination have been resorted to, X-rays are often of service in definitely establishing the diagnosis; when a growth is present, its size and position can be demonstrated, also the involvement of neighbouring organs and the possibility of operation. There are indeed few conditions where the advantages of early X-ray examination are so marked. The general practitioner who fails to have this examination carried out in a patient in whom he suspects the possibility of gastric cancer incurs a very heavy responsibility.

Sometimes it can be shown that malignant disease in other organs is the cause of pressure upon the stomach, causing symptoms that give the impression that this organ is involved.

Gastric Dilatation.—This condition gives rise to much discomfort and a feeling of ill-health of a more or less vague nature. The symptoms are indefinite and treatment often inclines to be also indefinite, owing to the difficulty of making a satisfactory diagnosis. X-ray examination often reveals the true state of things. Dilation is often found to depend on ptosis, with a want of muscular tone in the wall of the stomach and consequent great delay in emptying. This in turn may be complicated by fermentation and formation of gas in the interior of the stomach, with consequent discomfort to the patient. Bismuth food may be found in a stomach of this type six or even eight hours after a meal.

Gastroptosis.—This condition usually accompanies gastric dilatation. The stomach is seen to be displaced downwards, and may even lie in the pelvis. The condition is often associated with a general visceroptosis, and this in its turn is frequently associated with a condition of neurasthenia.

The Examination of the Small Intestine.—The patient should be prepared as for the examination of the stomach. The conditions for which examination is made are:

Duodenal Ulcer.—Normally the bismuth meal passes with great rapidity through the duodenum. In duodenal ulcer the emptying rate of the stomach is increased, in marked contrast to the delayed emptying in a number of cases of gastric and pyloric ulcer. The bismuth shadow in the duodenum is marked, because in duodenal ulcer the chyme is retained for a longer period than normal owing to spasm at the duodeno-jejunal junction, resulting in slight stasis.

Ilial Stasis.—The jejunum may share in a general visceroptosis, but it is not a very common condition. There may be dilatation of the ilium, and stasis due to obstruction at the ilio-cæcal valve, or to stricture of the ilium as a result of tubercular or malignant disease, or of chronic appendicitis, or of inflammatory conditions of the colon. Conditions of this kind are often very well demonstrated by the bismuth meal and the diagnosis established.

The Examination of the Vermiform Appendix.—A chronic inflammation of the appendix often exists and may give rise to reflex symptoms in other organs. The behaviour of the stomach and duodenum is often influenced, and adhesions in the neighbourhood of the colon and cæcum may be directly traced to repeated attacks of appendicitis. It is possible in most cases to cause bismuth food to pass into the appendix from the intestine, and in this way its condition can be investigated and information obtained as to its size, position, and shape, and whether it is adherent to other structures. It has been found that many obscure abdominal conditions and symptoms can be traced to a chronic inflammation of the appendix. Sometimes in obscure conditions the differential diagnosis between lesions of the appendix, kidney, colon, and gall-bladder can only be established by the radiographic expert. An abscess of the appendix can usually be demonstrated.

Malignant disease of the cæcum can also be demonstrated by the opaque-meal method. It is characterised by a persistent deformity of the shadow of the cæcum and obstruction to the passage of food from the small intestine.

The Examination of the Gall-bladder.—The diagnosis of gall-stones can usually be made clinically without the aid of radiography, but X-rays are sometimes necessary to establish a diagnosis between gall-stones and urinary calculus.

Gall-stones.—The demonstration of gall-stones calls for a special technique. When demonstrated they are seen on the negative as faint characteristic shadows in the region of the gall-bladder.

The Examination of the Large Intestine.—X-ray examination of the large intestine is daily becoming more common and forms an important part of a complete bismuth examination. The conditions calling for investigation are malignant growths, chronic constipation, stasis due to adhesions, etc., diverticulitis.

The **Cæcum** is examined in conjunction with the appendix. It is freely movable and may vary much in position. The rectum is usually examined by means of a bismuth enema.

Malignant growths can often be demonstrated by the bismuth meal. Ulceration and stricture are present, and often adhesions causing stasis.

Chronic Constipation.—Where this condition is obstinate and does not yield to treatment, examination by bismuth meal is useful to determine the cause of the constipation, whether due to visceroptosis, to adhesions, or malignant growths.

Stasis often exists in conjunction with a ptosed condition of the transverse colon. This is often found down in the pelvis, forming an acute angle at the hepatic and splenic flexures with delay of the bismuth meal at these points. This condition of stasis is frequently associated with chronic constipation.

Diverticulitis. — This condition gives rise to much vague abdominal discomfort and ill-health. There is sometimes a palpable mass in the left lower part of the abdomen. This is one of the conditions when X-ray examination is of great service in establishing the diagnosis, the X-ray picture being very characteristic. The opaque substance may persist in the diverticula for four or five days. The differential diagnosis between this condition and that of early new growth is very important.

C. Diseases of the Urinary System

As in the investigation of the alimentary canal, the information obtained from X-ray examination of the urinary system is often of the very greatest importance in establishing a diagnosis. The demonstration of a large calculus in the kidney is always sufficiently striking, as is also the outlining of the ureter and whole pelvis of the kidney when these have been injected with collargol and radiographed. When the symptoms point to a lesion in the region of the kidney, operative measures are seldom taken before a careful X-ray examination has been made of the urinary system, as so much valuable information can be obtained in this way.

Preparation of the Patient.—This is of great importance, as the presence of a loaded colon or rectum may obscure all results of the examination. The patient should be prepared as for operation. A good purgative must be given the night previous to the examination and an enema given shortly before. It is advisable that the purgative chosen be a vegetable one rather than a mineral, and it should be active enough to thoroughly clear the bowel.

The symptoms may depend on the presence of a small calculus in the ureter, and a small shadow caused by bowel contents in the intestine may lead to difficulty by obscuring the shadow of the stone.

The importance of a thorough evacuation of the bowels is appreciated when the fact is grasped that accumulations of fæcal matter in the intestines may throw shadows which may be mistaken for large stones, as may also foreign bodies in the intestine. Calcified mesenteric glands and phleboliths are also sometimes mistaken for calculi. Phleboliths are frequently found in the pelvis. The differential diagnosis between a phlebolith and a small stone in the ureter is very difficult. Points which aid in the diagnosis are:

(1) The size and shape of the shadow.
(2) The direction of its long axis.
(3) Its position.

Urinary Calculus.—Stone may be radiographed in the kidney, ureter, or bladder. The clinical symptoms will vary with the size and character of the stone, and full details of the history of the case should be furnished to the radiographer before examination.

A stone may sometimes be studied radiographically during its passage down the ureter, and every opportunity should be given for this to occur before an operation is undertaken. When a stone has been radiographed in the ureter and operation contemplated, a second radiograph should be taken just before operation, and the point definitely established, by the passage of an opaque bougie, that the stone is actually in the lumen of the ureter.

Malignant Disease.—Sarcoma, hypernephroma, and carcinoma are the forms of malignant disease met with in the kidney. Carcinoma is not common. The tumour may grow to a large size. Swelling is noticed in the loin, preserving more or less the shape of the kidney. Sometimes the characteristic anterior notch can be felt. Simple tumour of the kidney is usually cystic in nature. The cysts may be numerous and the whole organ be eventually involved and attain to a great size.

X-rays are of service in these cases in excluding the presence of a stone, and indicating the presence of fluid in the enlarged kidney. Tubercular disease also causes enlargement of the kidney, and the differential diagnosis between tubercle and cyst may be difficult. Radiography will help, as when caseous matter is formed, or an abscess exists, the negative will demonstrate these, and this evidence in conjunction with the clinical signs of tuberculosis will establish the diagnosis. Tuberculosis of the kidney may, when healing has occurred, leave calcareous masses in the organ. These are very difficult sometimes to distinguish from calculi.

The presence of a stone in the bladder is as a rule easily demonstrated by X-rays, and it is always advisable to send for radiographic examination a patient in whom this condition is suspected.

Pyonephrosis, or pus in the kidney, may occasionally be detected, when present in bulk, by X-rays. It throws a shadow inside the kidney shadow not defined and clear-cut as in a calculus, but irregular with ill-defined edges. The organ will be enlarged.

Unusual conditions such as hydatid and

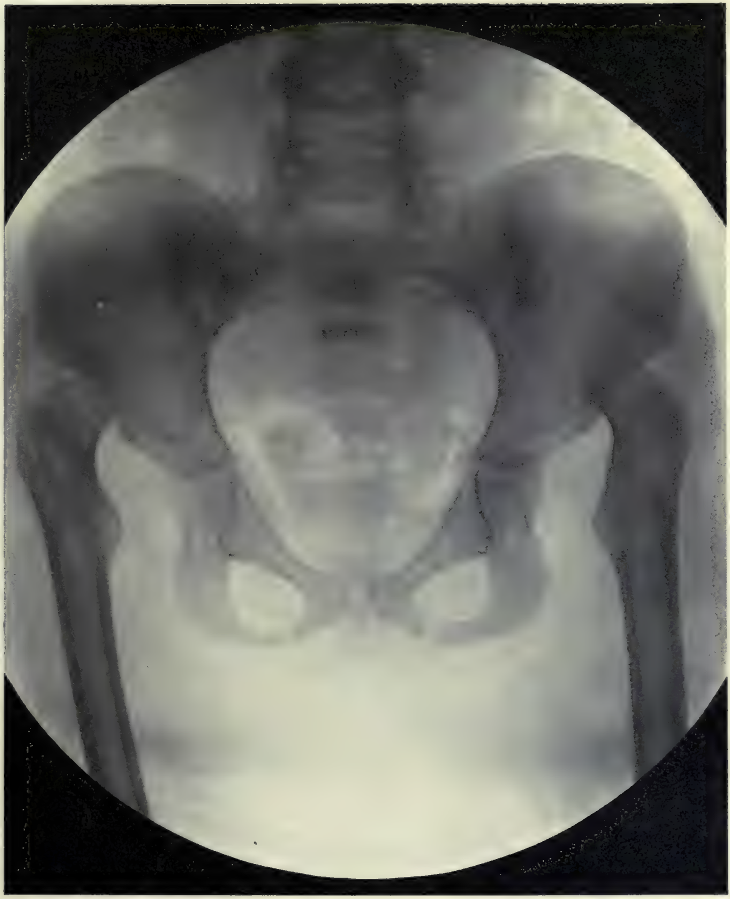
dermoid cysts in the kidney can be demonstrated, though when they are met with they give rise to great difficulty in diagnosis.

In doubtful cases of kidney disease the pelvis of the organ can be injected with opaque material (collargol, solution of sodium bromide, etc.). When radiographed the size and position of the pelvis of the kidney can be demonstrated.

In diseases of the urinary system radiography can thus be of great assistance to the general practitioner in two ways: (1) to confirm a diagnosis of suspected stone or cyst; (2) to establish a diagnosis in obscure and uncertain cases.

Thus a patient may have a history of pain in the left side with swelling and tenderness, and a radiograph may show no calculus in kidney or ureter but a shadow whose appearance suggests the presence of pus. Further examination may demonstrate the presence of a pelvic abscess, or a condition of diverticulitis of the descending colon. In all cases every clinical point should be given to the radiographer, with a full history of the illness and details of any operations which may have been performed.

The patient should also be prepared for an examination to be made of both kidneys. If trouble is suspected or found in one kidney it is very important that the condition of the other kidney should be inquired into before any



PELVIS SHOWING CONGENITAL DISLOCATION OF BOTH HIP-JOINTS.

operative measures are undertaken. Moreover, examination of both kidneys is important, as occasionally it is found that symptoms are referred to one side while the lesion is situated on the other.

For these reasons it is always wise to ask for a complete examination of the whole of the urinary tract when sending a patient for X-ray examination.

D. Diseases of the Pelvis

For detecting deformities of the bony wall of the pelvis X-rays are of great use, and may thus be usefully employed in checking pelvic measurements for obstetric purposes, especially when stereoscopic plates are used. Pregnancy can be diagnosed radiographically after the fourth month.

The bladder, the uterus, ovaries, and Fallopian tubes may all require radiographic examination. These organs are usually surveyed when a radiograph of the pelvis is taken, but if definite disease is suspected it is well to inform the radiologist of the fact, that he may carefully examine the pelvis for unusual shadows.

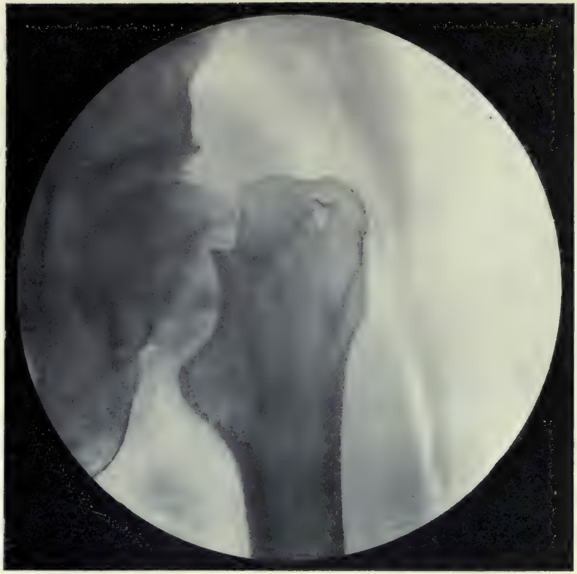
X-rays are probably of most use in establishing the diagnosis in obscure and doubtful conditions of the pelvis. Thus symptoms indistinguishable from those of uretral colic may exist, and a radiogram may show a shadow indicating tumour of the ovary with portions of bone or teeth demonstrating a dermoid cyst.

A case of chronic appendicitis with extensive adhesions may present symptoms suggestive of inflammation of the ovary. X-ray examination reveals the true condition, when an opaque meal is used.

Tumours—frequently malignant—may occur in any part of the pelvis, either originating in the bony structure or invading this as an extension from a primary growth in the soft parts. Arthritic conditions in the sacrum, sacro-iliac synchondrosis, coccyx and hip joints, may simulate malignant disease, and X-rays will be very helpful in distinguishing the condition.

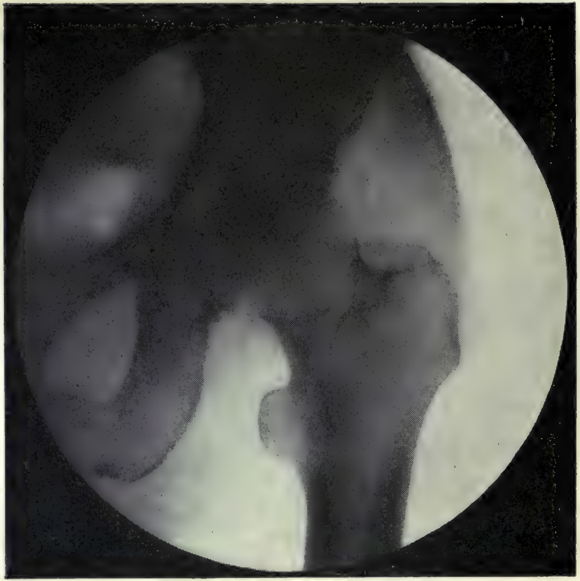
Again, chronic appendicitis may be diagnosed by the demonstration of concretions in the lumen, and in this connection it may be mentioned that the cæcum and appendix may occasionally be found on the left side instead of on the right, owing to transposition of the viscera. The presence of such a condition can be definitely ascertained by the administration of an opaque meal. Plate VII. illustrates a case of this kind. Again, when a condition of fibromyoma of the uterus exists, and the question of operation or X-ray treatment is under discussion, a radiographic examination may reveal a condition of

PLATE XVII.



FRACTURE OF NECK OF FEMUR.

With upward displacement of shaft of the femur.



NORMAL HIP-JOINT.

calcification of the fibroid, and this is an important indication for operative measures to be adopted, rather than treatment by X-rays, because when this condition exists there is little likelihood of the patient receiving benefit from treatment.

Foreign bodies in the pelvic organs can be demonstrated by X-rays. Thus hair-pins and other similar bodies have been found in the bladder and in the vagina and uterus, having possibly been used with intent to procure abortion. In one case a pipe-stem was the nucleus of a large calculus situated in the bladder. A case is on record when a patient was radiographed for obscure pelvic symptoms, and a pessary, introduced years before and forgotten, was demonstrated. This is by no means an uncommon occurrence—every practitioner at one time or another has met with the forgotten pessary. It should not, however, often be necessary to resort to X-rays to clear up the diagnosis.

E. INJURIES AND DISEASES OF BONES AND JOINTS

Injuries of Bones and Joints

X-rays have from the very first been employed in the diagnosis of injuries to bones and joints, long before the improvements in apparatus and technique permitted of the elaborate examinations of soft parts and the internal organs which are now so general. Nowadays in nearly all severe injuries involving the shaft of a long bone or a joint the patient is sent for radiographic examination. The advantages of this are obvious. In an injury to the shaft of a long bone a radiograph reveals clearly the character and extent of the injury, showing whether the fracture involves the whole bone, and the position of the fragments, whether there is much displacement and overriding of the fragments, indicating the probability of much permanent shortening. Moreover a radiograph taken after the fracture has been set will show if the position is as good as can be hoped for.

In the case of a fractured shaft it is wise to have a second radiograph taken after several weeks. This shows the character and extent of the union that has occurred, whether there is much callus, and whether the general condition of the limb is satisfactory.

X-rays are perhaps of most value in cases of severe injury, where fracture seems probable but cannot easily be diagnosed by ordinary observation. Thus a severe fall or blow on the shoulder is a common injury, and X-rays will often show a fracture of the greater or the lesser tuberosity, without there being at first sight marked loss of power or any deformity. Without a radiogram, fracture might not be diagnosed for some days, until the loss of power, discoloration, and pain make it obvious that the injury is more severe than was at first supposed. Severe injuries to the limbs in young children should always be radiographed in case the epiphyses of the bones have been separated or injured.

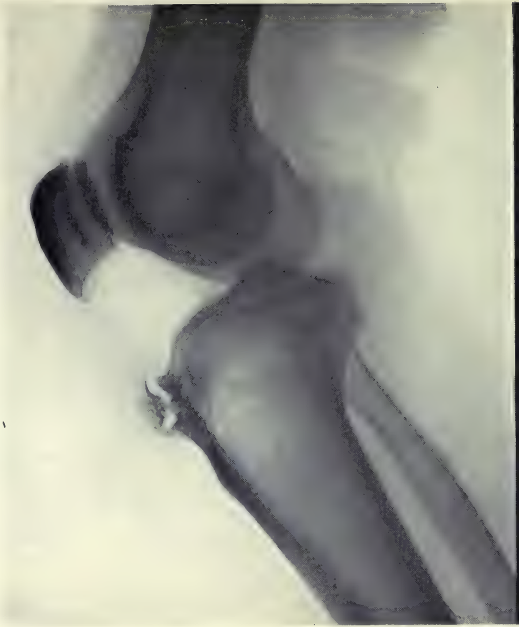
All injuries involving a joint should be radiographed. It is of great importance to know as early as possible whether a dislocation of a joint is complicated by any fracture in one of the bones entering into the joint, because of the question of a permanent impairment of usefulness. Many instances have occurred of permanent deformity, loss of power, and of greatly prolonged incapacity, owing to the fact that the full extent of the injury has not been recognised at the first examination and treatment. Cases of fracture and dislocation have been treated solely as cases of dislocation and the fracture not recognised perhaps for weeks afterwards; by that time permanent deformity may have resulted, or, at any rate, so much contraction and wasting of muscle that it takes months of massage and treatment to restore the full use of the limb.

At the present time, with the help of X-rays available practically everywhere, there is really no excuse for the non-recognition of the full extent of an injury to bones and joints.

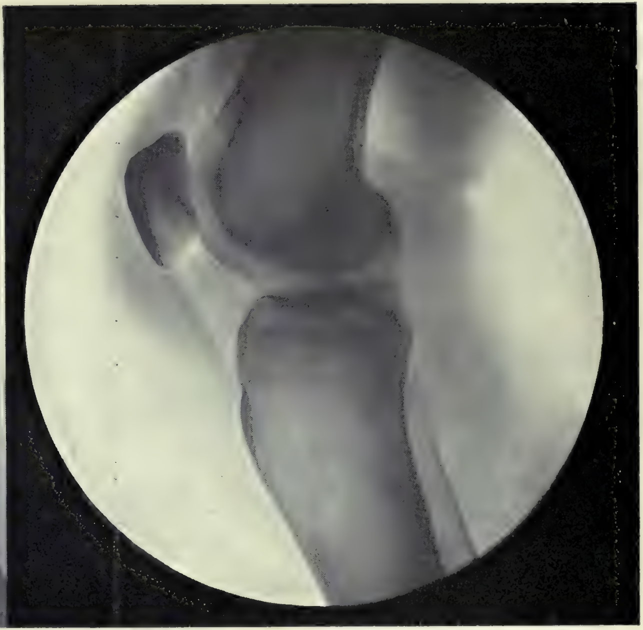
When sending a patient for radiographic examination of a suspected fracture or dislocation, the medical practitioner should, if possible, accompany the patient, as in most cases the splints and dressings must be taken down. It is sometimes possible for the radiograph to be taken through the bandages, etc., but the patient must always be prepared for them to be removed. It is therefore wise for the medical man in charge to be present. Fractures of the leg, spine, and pelvis can be radiographed at the patient's house by means of a portable outfit.

In all cases of accident the need for X-ray examination from a medico-legal aspect may be noted. It is often of great advantage to have a radiograph taken of the affected part. It should be remembered that in court *the plate alone* is accepted as evidence, and this plate must have been marked at the time it was taken by the person who will give evidence. Prints and diagrams may be used to illustrate points, but the plate must be produced.

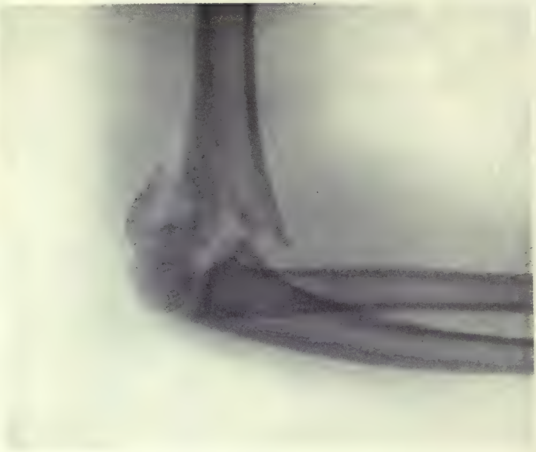
In all cases of injury where legal proceedings are likely to follow, it is wise to have radiographs taken as soon after injury as possible,



Old injury to tubercle of tibia with periosteal thickenings and an interva between the surfaces of bone. (Schlatter's disease.)

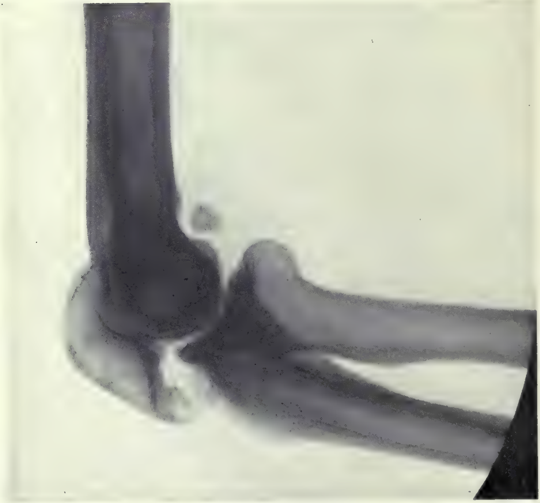


Knee-joint showing enlargement in front of the patella (synovitis of the bursa patellæ).



FRACTURE AT LOWER END OF HUMERUS.

With backward displacement at elbow-joint.



FRACTURE OF THE OLECRANON PROCESS OF ULNA.

Note at front of joint small portion of bone detached from the internal condyle.

and these plates should be kept and produced as evidence.

It is well for the practitioner in all cases of injury to advise X-ray examination so that the full extent of the damage may be recognised from the beginning. If this is done and the case does badly, the practitioner is safeguarded from the suggestion that the real injury had not been diagnosed. This rule should be followed out in all cases of injury, however slight, in the neighbourhood of a joint. This is particularly the case in injuries occurring in children. Traumatic arthritis often follows such an injury, and this may be the site of a future tubercular lesion.

Patients who complain of severe pain and loss of power in a bone after very trivial injury should be radiographed, as these may be instances of spontaneous fracture due to fragility of the bone, or the examination may reveal evidences of new growth of the bone hitherto unsuspected. Another advantage of early X-ray examination of a fracture is that it is sometimes possible, where the radiograph shows a faulty position, to reset the fracture in a more favourable position under the rays.

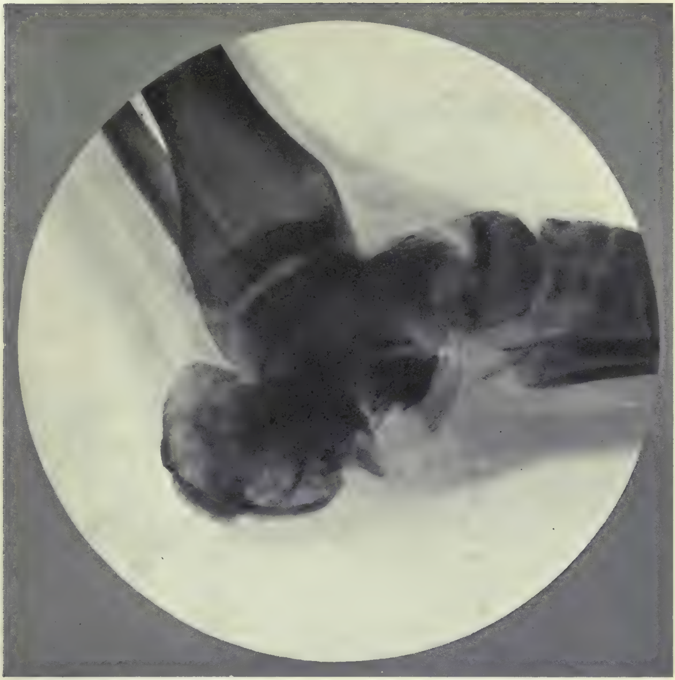
It is well here to say that while the value of a screen examination of an injury is recognised, plates should also always be taken. The medical man in charge of the case should never be satisfied with a negative report based only on screen examination without plates. Cases are constantly occurring where such a report has been accepted and treatment carried out based on it, and plate examination at a later date reveals the presence of a fracture without displacement.

Diseases of Bones and Joints

In recent years X-rays have been extensively used in the diagnosis of many diseases of bone. The fact that such help is available should be more widely known and appreciated than it is among general practitioners. In some diseases of bone, tuberculosis for example, it is of the utmost importance for prognosis and treatment that the character and extent of the disease should be recognised at the earliest possible stage. A good radiograph will often show such changes in the bone tissue that a diagnosis can be made and suitable treatment adopted while the clinical symptoms are still so slight that from them the disease may only be vaguely suspected.

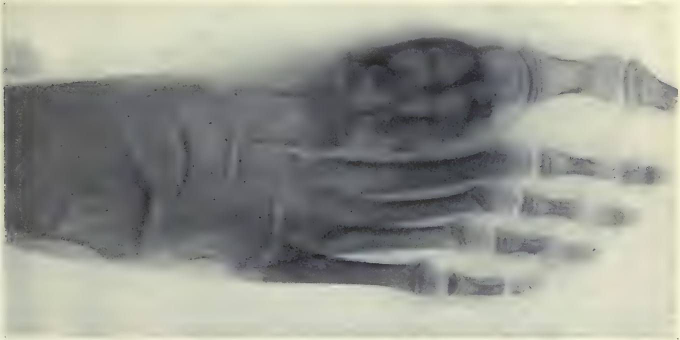
This point is of very great importance in the case of children and will be dealt with more fully in the section on radiography of children.

X-rays are also of great assistance in establish-



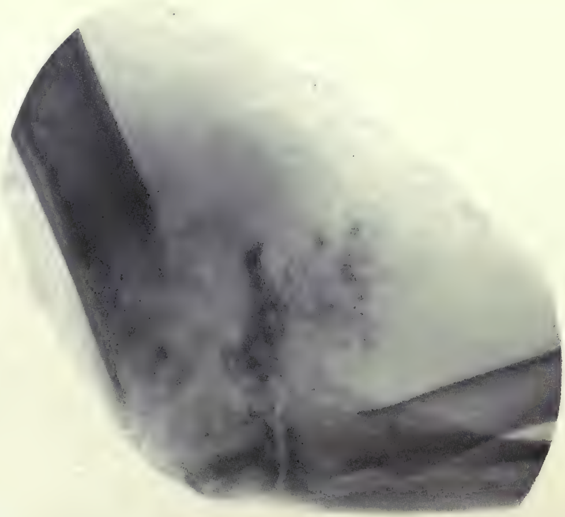
REGION OF ANKLE-JOINT.

Showing extensive injury to os calcis with secondary osteitis and formation of sequestra.

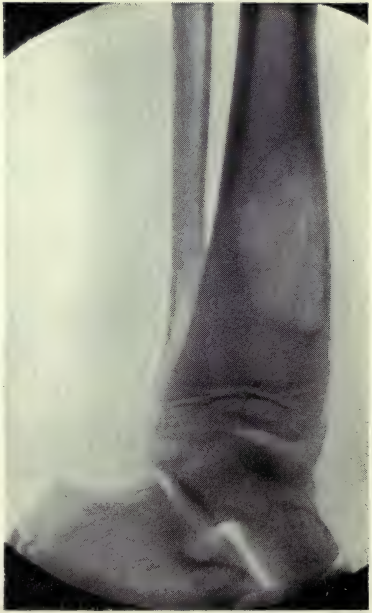


FOOT.

Showing cystic disease of the metatarsal bone of the great toe (myeloma).



EXTENSIVE SARCOMA AT LOWER END OF HUMERUS, INVOLVING THE ELBOW-JOINT.



CHONDRO-SARCOMA OF LOWER END OF TIBIA.

ing a diagnosis of tumour of bone both in simple tumours and those of a malignant nature, and in exostosis and chondromata, swellings which often alarm patients a good deal, and may perplex the practitioner to a certain extent. It is well to remember that X-rays will in most of these cases clear up the nature of the swelling and reassure the patient.

Malignant tumours of bone are usually either sarcomata or carcinomata, the latter secondary to a malignant process elsewhere. In the early stages sarcoma of bone may be very difficult to diagnose from syphilitic or inflammatory affections. Inflammatory processes with abscess formation give characteristic radiographic appearances, as do also arthritic processes whether rheumatoid or hypertrophic. In cases of osteomyelitis, either acute or chronic, the extent and progress of the disease can be demonstrated radiographically and the presence of sequestra shown.

It may be said that in any case of disease of a bone or joint which is somewhat obscure, it is probable that X-rays will help in establishing the diagnosis, and in cases where the diagnosis is plain, the extent and progress of the disease can be recorded.

The demonstration of sequestra has been brought into prominence during recent years, owing to the large number of cases of bone injuries and inflammation resulting from war injuries. Many cases are sent again and again for radiographic examination in order that the progress may be estimated. Very valuable information as to the condition of the bone, the presence of sequestra, and the advisability or not of operative interference has been obtained in this way.

The viewing by means of radiographs of the progress towards healing, or the reverse, in a diseased bone is a very important advance in modern surgery and one to which more and more attention will be paid. Few things are more helpful, for example, to a surgeon who has advised a child to be put in an extension apparatus for early tubercular disease of the hip, than to be able to actually watch, by radiograms taken from time to time, the process of arrest of the disease. Relatives who are anxiously inclined to think the time for complete rest in an extension long, and to fear that this time may in the end prove to have been wasted, are not nearly so likely to be impatient if they feel that every few months the actual condition of the parts can be seen and studied by the surgeon.

It may be noted that it is now becoming a usual practice, in cases where a mechanical extension apparatus is applied to a limb for disease or injury, to radiograph the limb before and after the application of the apparatus, and thus study how far the extension fulfils the purpose for which it is applied.

Moreover, X-rays are of great service in distinguishing between tuberculous and non-tuberculous inflammations. The X-ray appearance of acute and sub-acute osteomyelitis can be differentiated from those of tubercle. This is often a point of much importance to the general practitioner, as the clinical symptoms and course may be much the same.

Again, in many cases it is wise to have joints which have been the seat of slight injury radiographed. Changes due to the injury may be detected, and these may later become the seat of tubercular lesions.

In delicate people with history of tubercle in the family, radiographs after injuries may give very useful information.

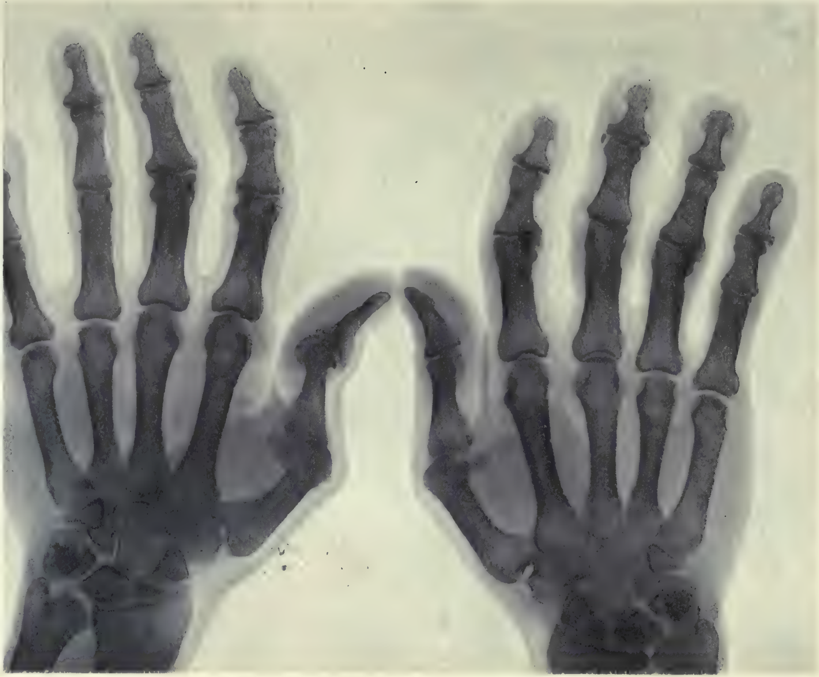
The principal diseases of bones and joints in which X-rays are useful are tuberculosis, syphilis, osteomyelitis, and sarcoma. It may be well to describe a few typical examples of these diseases from a clinical and radiological point of view, showing at what stages radiograms will be helpful. Rickets will be dealt with in the section on children.

Tuberculosis of the Hip-Joint.—This disease may commence in the synovial membrane, or in the articular ends of the bones entering into the joint, or it may be an extension from a tubercular periostitis. The early manifestations are very slight and the disease may have made considerable progress before much notice is taken. The first symptoms noticed are slight limitations of movement, with some pain if the limb is jarred or twisted. In this stage the synovial membrane is thickened and œdematous, and presents numerous gelatinous nodules just under the serous lining. These may coalesce and form caseous masses and sometimes burst into the joint, leaving ulcerated surfaces behind.

Finally the whole synovial membrane may become converted into a pyogenic membrane and the articular surfaces of the cartilages become gradually eroded. The whole thickness of the cartilage may be affected and the cancellous tissue of the bone become involved. Eventually large flakes of bone may necrose and be shelled off. Sometimes in the early stages there is much effusion, but in most cases the joint is largely occupied by the swollen synovial membrane.

When a tubercular hip-joint is examined radiographically it shows marked departures from the normal, if the disease is at all advanced.

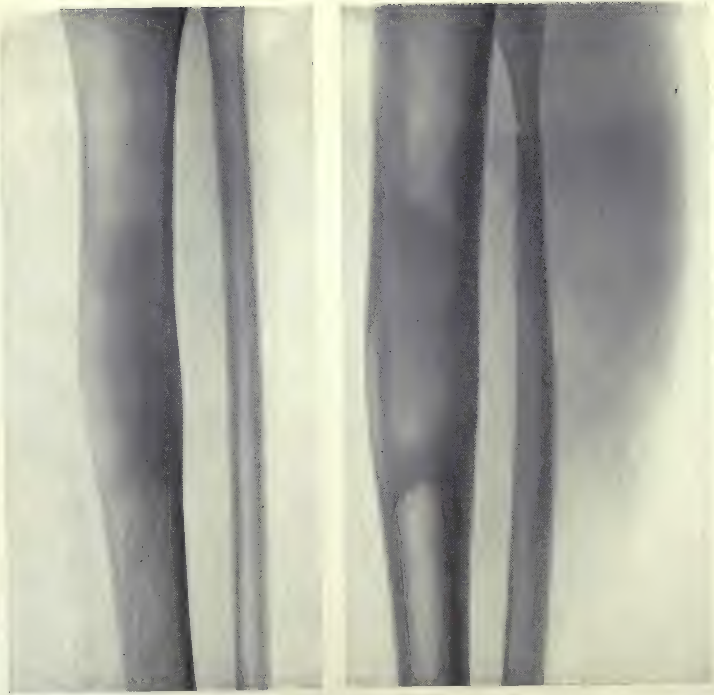
PLATE XXII.



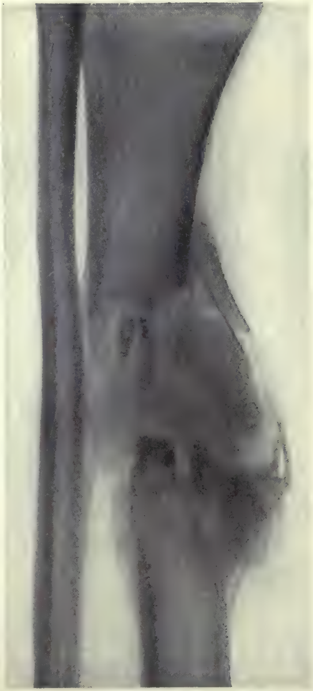
HANDS OF PROFESSIONAL WICKET-KEEPER.

Showing extensive changes in the joints, particularly the thumb of the right hand (left of picture). Note also extensive rheumatoid arthritis of the phalangeal joints of both hands.

PLATE XXIII.



Antero-posterior and lateral views of myeloid sarcoma of the shaft of the tibia. The radiographic diagnosis suggested a large sequestrum and at the operation a central sequestrum was removed; on examination this was found to be due to myeloid sarcoma.



Gunshot injury of the tibia, showing extensive new bone formation with sequestra.

The swelling of the synovial membrane and the erosion of cartilage and bone, and the caseous material in the cavity of the joint, can all be demonstrated. Moreover, the surrounding bones, particularly those entering into the joint, show atrophic changes. In the very early stages, before there is any pus formation or destructive osteitis, the radiographic appearances may be practically normal, and when the clinical evidence indicates tubercle a negative plate should not be accepted as final, but the patient be examined from time to time. In the later stages the appearances are very characteristic and the diagnosis can be completely established. Bones in the region of a diseased joint frequently become rarefied. This is due to absorption of the lime salts, and may be secondary to disease or a septic condition of the bone.

Tuberculosis of the Knee-Joint.—This joint is perhaps more subject to invasion by tubercle than any other in the body, and in this joint especially traumatism, such as fracture of the spine of the tibia or tearing of the crucial ligaments, may cause changes in the tissues which eventually become tubercular.

The X-ray appearances are very characteristic. There is often much fluid in the early stages and the perisynovial tissues are much involved; they become infiltrated and gelatinous, muscles and tendons sharing in the modification. The fluid in the joint and the altered perisynovial tissues together form what is commonly known as the " white swelling."

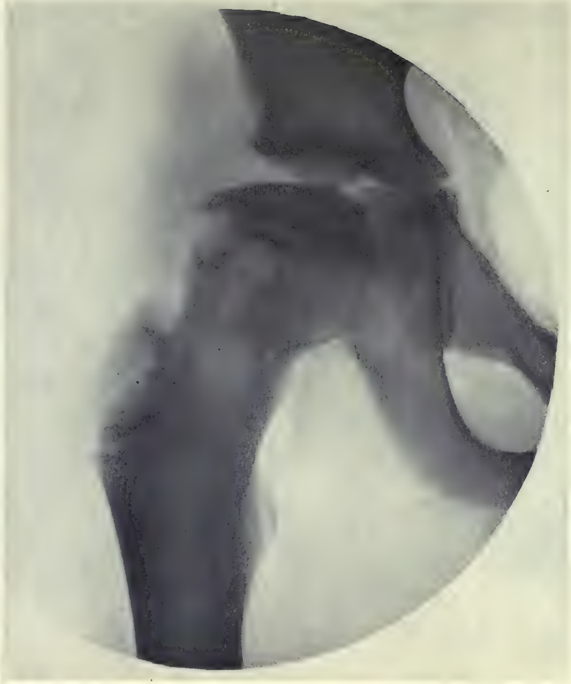
The radiographic appearances of a tubercular knee at a later stage are similar to those found in the hip- and other joints. In children a roughening of the epiphysis of the former may be demonstrated before there is any destruction of bone, but as a rule atrophy in the shaft of the femur and tibia can be noticed at this stage.

Tubercular lesions of the ankle, elbow, and wrist all give similar characteristic radiographic appearances, and doubtful cases should always be submitted to X-rays.

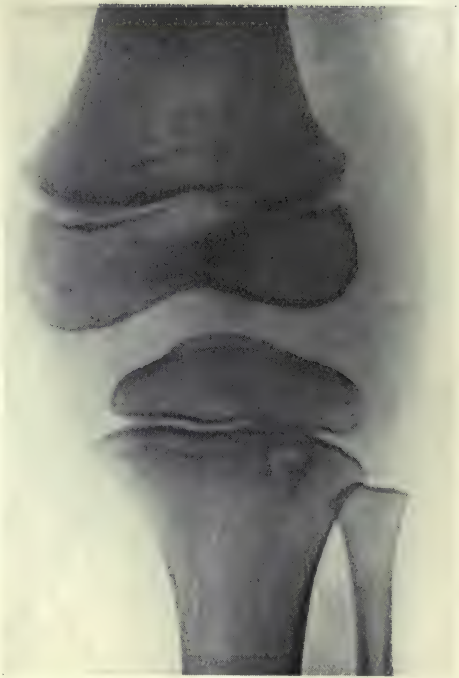
Tuberculosis of the Spine.—This is a common complaint. The X-ray appearances are characteristic and are of much assistance in establishing the diagnosis when clinically this is a matter of difficulty. Early cases may require to be diagnosed from arthritis, from osteomyelitis, and from tumour involving the spine.

Tuberculous caries often ends in abscess formation, and this can in most cases be readily demonstrated by X-rays (see Plate XXV., Psoas Abscess).

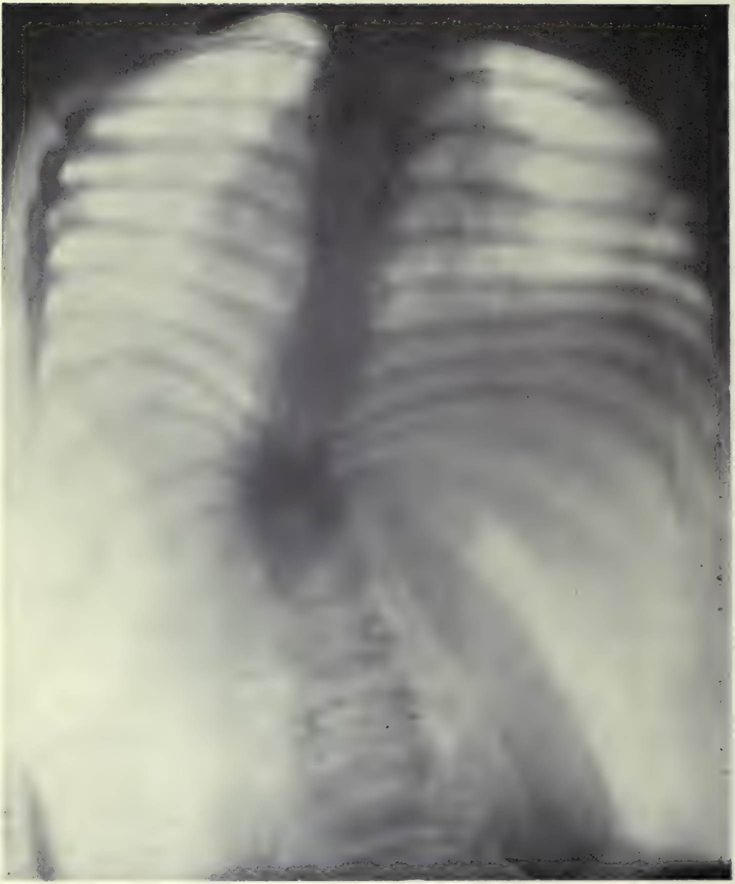
The tubercular process attacks almost exclusively the bodies of the vertebral and the intervertebral cartilages. Before pus formation



1. Plate showing chronic changes in hip-joint, irregularly of the epiphysis with condensation of bone, and rarefied areas in the diaphysis close to the epiphyseal line.



2. Knee-joint of a child showing epiphyses. At the upper end of the tibia, close to the epiphyseal line, the clear area surrounded by a ring of condensed bone indicates the seat of an abscess.



EXTENSIVE CARIES OF LOWER DORSAL AND UPPER LUMBAR VERTEBRÆ (OLD TUBERCULOUS DISEASE).

The elongated shadow to the right of the spine is due to the presence of a psoas abscess.

has occurred, areas of increased radiability can be made out, later on areas of increased density show localised abscesses in the bone, and finally a disappearance of the cartilage and a crushing together of the vertebræ can be demonstrated.

Osteomyelitis.—This disease is an inflammation of bone, not due to one specific organism alone but to the action of one or more organisms, and affecting not only the periosteum but also the cortex of the bone and the medullary cavity. It is of some importance because of the great destruction of bone and consequent permanent deformity which may follow, especially if the diagnosis is not quickly made and the appropriate treatment employed.

Where the clinical symptoms are slight or obscure, a radiographic examination is often of the greatest possible help, especially in young children, in establishing the differential diagnosis between osteomyelitis, tubercle, and rheumatic fever. Rotch, of Harvard University, points out that " there is more confusion in the mind of the general practitioner in regard to rheumatic fever in connection with this set of cases than arises when a differential diagnosis is to be made from any other disease. For this reason the organism which may be producing an osteomyelitis has an opportunity to thoroughly infect the bone, and often to such an extent that operative treatment becomes of little avail."

Any of the bones may be attacked by osteomyelitis, but those in the neighbourhood of the knee are the most common seat of infection. It commonly attacks the long bones, and usually the extremities of these. "The primary infection may be in the periosteum or the medulla according to the site of infection and the tissues involved. If in the periosteum, this is thickened and hypertrophied, even ragged, exposing the cortex ;—if in the medulla, the affected area shows very early patches of different and definite degrees of density with increased radiability where the destruction of the bone and absorption of lime salts are taking place. Differentiating between tuberculosis or syphilis, osteomyelitis is characterised by the greater proliferation of the periosteum and the marked tendency to the formation of new bone in the area of necrosis."

Syphilitic Diseases of Bones.—The help of X-rays may be required in establishing the differential diagnosis between syphilitic and tubercular disease of bone.

Tertiary manifestations of acquired syphilis and forms of congenital syphilis are the most likely to cause an error in diagnosis.

A radiograph will demonstrate the difference between the destruction of bone, and lesions in the joint in tuberculosis, and the marked overgrowth of the periosteum, layer upon layer, found in syphilis.

Clinically, a case of syphilitic dactylitis will closely resemble one of tubercular dactylitis, but radiographically the differential diagnosis is clear.

Radiography in Diseases of the Head and Neck.—Radiography of the accessory sinuses of the head is now very usually resorted to when disease in these regions is suspected. Abscesses in the frontal sinus, the antrum of Highmore, or the sphenoidal sinus can be demonstrated, as can also polypi. In cases where the differential diagnosis between abscess and tumour is obscure, X-rays may decide the matter. Tumour in the pituitary fossa can be demonstrated, also tumours or abscesses in the brain substance. In the case of abscess or tumour of the brain a good radiogram may be the determining factor in deciding whether or not to operate.

Radiography is also largely made use of now to clear up difficult points in dental diagnosis.

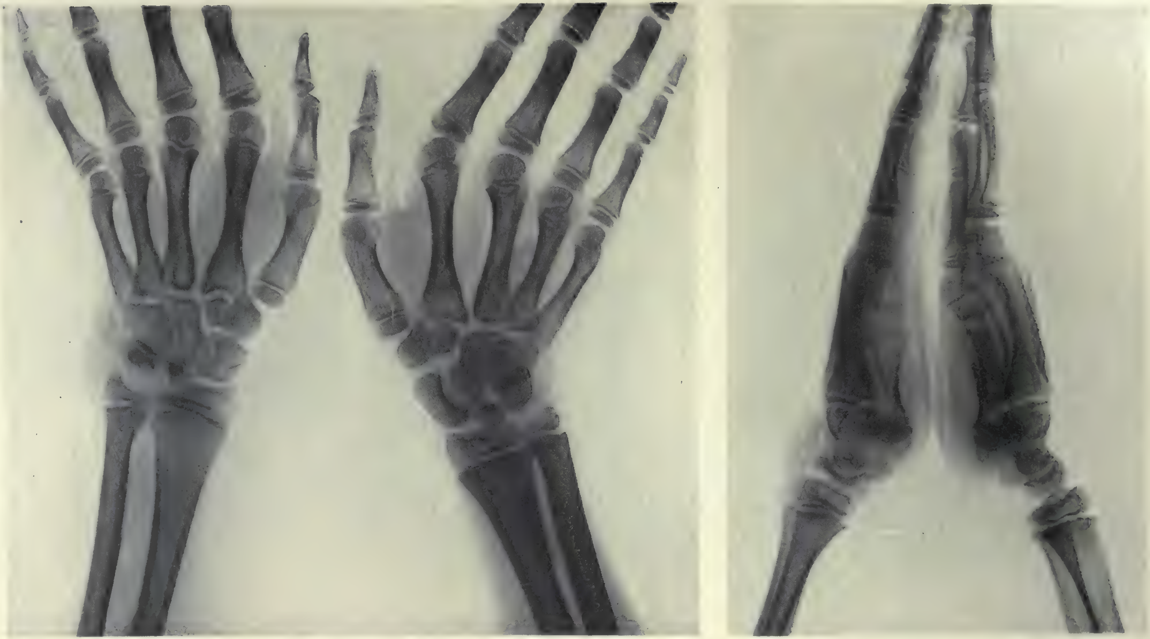
CHAPTER III

X-RAYS IN THE DIAGNOSIS AND TREATMENT OF DISEASES AND INJURIES OF CHILDREN

The Infant.—Very young children, sometimes only a few weeks old, are now not infrequently submitted to X-ray examination and radiation treatment. Radiographic examination is advisable in cases of persistent vomiting, where no diet suits and the infant is obviously wasting. A few spoonfuls of milk with some bismuth preparation are given, and if pyloric stenosis is present it can usually be detected.

X-ray examination is also in request when the infant has accidentally swallowed a foreign body. The position can be located and the question decided as to whether immediate operative interference is called for, and also repeated radiographs will show if the foreign body remains stationary or shifts its position. Sometimes the withdrawal of the foreign body can be guided by the rays (see page 14).

PLATE XXVI.

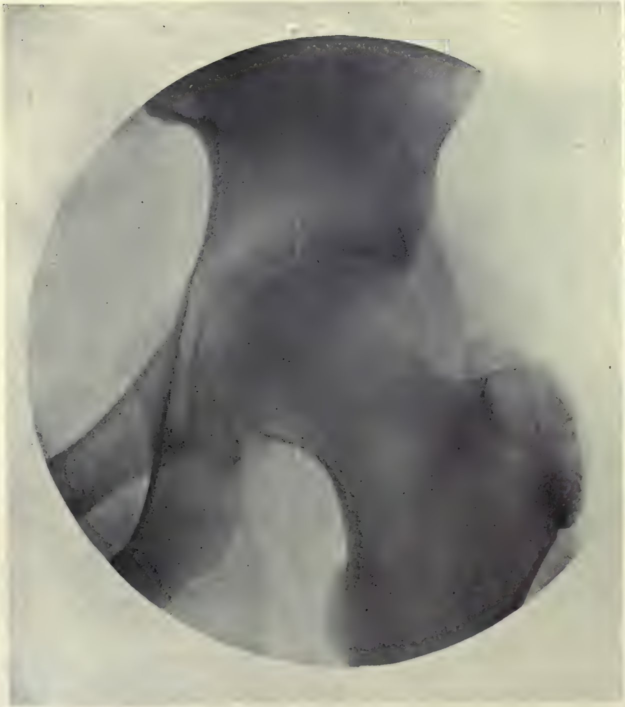


A. Antero-posterior view.

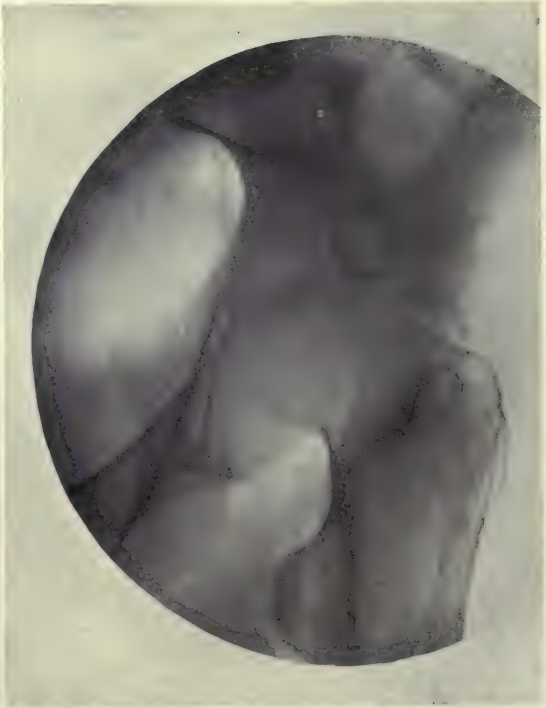
B. Lateral view.

Tuberculous disease of wrist-joint, showing extensive changes in carpal bones, scaphoid and semilunar chiefly, and in the outer portion of epiphysis of the lower end of the radius. The swelling of the soft parts indicates abscess formation. In both illustrations the normal joints are shown for comparison.

PLATE XXVII



Hip-joint showing very early changes in acetabulum and head of femur. Note also changes in great trochanter.



The same case nine months later showing extensive changes in hip-joint, displacement upwards of bone, partial absorption head, and rarefaction of portion of neck.

Radiation treatment in infants is usually called for in cases of rapidly growing nævi. Radium is generally the agent employed and is, as a rule, very successful. Radiations are also employed in the treatment of hairy moles, and in cases where persistent thymus gland causes distressing symptoms.

Diagnosis in Children.—The diseases in children in which X-ray diagnosis is of use are much the same as in adults, and X-rays are often of great service in establishing the diagnosis in cases where the differential diagnosis is difficult. Thus there may be difficulty in differentiating between a case of rickets and one of congenital syphilis, between persistent thymus and mediastinal tumour, or between early tuberculosis of bone and sarcoma. In all such cases X-rays are often of the greatest assistance and should be used.

The early diagnosis of incipient tubercular disease of the hip-joint is a point of the greatest importance, upon which the future welfare of a child may depend, and in cases where the clinical signs are slight, but suspicious, repeated radiographs taken at intervals of a few weeks or months may establish the diagnosis beyond all doubt. Again, in cases of slight pyrexia and wasting, with little cough and no expectoration, repeated radiographs of the chest may show a group of tubercular deep-seated glands, or isolated patches of mischief, the detection of which may modify the whole line of treatment.

Tubercular glands in children are now often treated by X-rays with very successful results. Treatment should be thorough and carried out over a long period of time.

The majority of cases of accident, with injuries to limbs, in children should be radiographed to ascertain if there is any greenstick fracture, or any separation of the epiphysis. This is a common accident in young children and may lead to serious consequences. In dealing with children, quickness of work and instantaneous radiographs are points of importance, otherwise the details may be blurred owing to restless movements.

Many of the conditions treated in adults by X-rays occur in children and have been dealt with elsewhere. The details of technique and treatment are essentially the same.

Sarcomata may occur in the larger of the long bones or in the bones of the head.

Radiographic changes difficult to distinguish from those in osteomyelitis are found, and areas of increased density may appear, or sometimes actual absorption of bone; there is often a marked increase of tissue.

Rickets.—Rickets is a disease of early childhood characterised by a disturbance of the normal processes of ossification of the bones, the exact cause of which is still unknown. This disturbance results in the production of an irregular spongy bone tissue instead of the normal compact lamellated bone tissue. The increased cell growth between the epiphyses and the diaphyses produces the knobby swellings so characteristic of rickets.

Clinically the disease is familiar to all practitioners. Radiographically the bones present a quite characteristic picture. There is great irregularity of the epiphyseal lines, with hyperplasia of the osteoid tissue and hypertrophy of the epiphyseal cartilage. The curves in the shafts of the bones are often greatly exaggerated.

The zone of proliferation is wider than normal, with irregular deposits of bone on the epiphyseal side, giving a toothed appearance to the diaphysis. There is also definite thickening of the periosteum.

The changes in the bones are a thinning of the cortex with an irregular deposit of bone cells of irregular outline, an enlargement of the medullary cavity, and a rearrangement of the bone structure.

Occasionally a cystic formation of bone is found. Radiographically several types of rachitic deformity of bone can be distinguished.

From the point of view of the general practitioner it is important to note that the changes in the osseous system can be detected radiologically *before* they become clinically evident.

CHAPTER IV

X-RAYS IN TREATMENT

The extensive use of X-rays in the treatment of disease is a development of recent years, and is the outcome of the fact that very early X-rays were found to have a harmful effect on tissues. This led to a study of their action on cells and a gradual appreciation of the fact that many morbid conditions of the body could be influenced by radiations.

Since that time there has been steady research work carried out in the field of radiotherapeutics, and each improvement in technique has been followed by an extension of radiotherapy. Now treatment is no longer confined to external lesions of the skin. Deep-seated organs, such as the ovaries and uterus, are amenable to X-ray treatment, and in some obscure diseases of the blood and nervous system there is every reason to think, from the results now obtained from ray therapy, that in radium and X-rays we have most powerful curative agents.

The general practitioner should be fully alive to the possibilities of radiotherapy, so often does it already mean (and as time goes on will mean more and more) that he can offer a patient an alternative treatment to the operative one, and no class of medical man knows better than he how deeply many patients shrink from an operation and its risks and mutilation, and how eagerly they welcome the prospect of other treatment if equal prospect of success attends it.

The practitioner should also endeavour to grasp the fact that in the practice of medicine X-rays, in an ever-increasing number of diseases, will act as a powerful coadjutor to other lines of treatment, *e.g.* rest, drugs, and diet, and that by the combined action results may in a number of instances be obtained in half the time required by the use of any one of them alone.

THE TREATMENT OF DISEASE

There are many diseased conditions where treatment by radiations is of great use. Stress must be laid on the point that, in considering the treatment of disease by X-rays, there is no question which calls for greater care and discrimination on the part of the general practitioner than the selection of the cases sent for radiation treatment. The selection of a suitable case enables the radiologist to employ the therapeutic power of the rays to the greatest possible extent, and so to reflect credit upon the practitioner, while if an unsuitable case is treated, disappointment is the inevitable result. In a number of hopeless cases the practitioner may advise radiation treatment for the relief of symptoms, and in such cases he should be careful to point out the limitations of the treatment, and that it is palliative only. The treatment may be considered under three heads.

(1) Curative—where it is hoped to entirely arrest the progress of the disease ; as, for instance, in exophthalmic goitre, where X-ray treatment can bring about a diminution in the size of the thyroid gland with marked beneficial effects on the constitutional symptoms ; or, again, in the treatment of enlarged tuberculous glands. These are often very amenable to X-rays, an intensification of the natural process of cure being observed in very favourable cases, namely, a tendency to fibrosis resulting in a marked diminution in the size of the gland, and its ultimate disappearance.

(2) Palliative—to relieve distressing symptoms in incurable conditions. This is especially marked in some forms of malignant disease ; in inoperable growths remarkable local effects can often be obtained by means of X-rays. They are

useful to (*a*) temporarily arrest the progress of the disease; (*b*) check discharges and lessen pain; (*c*) clean up foul discharging sores. For example, a case of inoperable carcinoma of the breast, with ulceration and offensive discharge, will often quite clear up for a time after treatment. Sometimes, also, a growth which at first seemed quite hopeless from an operative point of view can be so much reduced in size by X-ray treatment that an operation for removal can be undertaken. In carcinoma of the cervix uteri the temporary relief and improvement that can be obtained by radium treatment are often wonderful. This improvement may be greatly aided by the use of X-rays, applied through the abdominal walls, the aim being to act upon the deep glands and the intervening tissues. Cases of hopeless malignant disease, where the surgeon can do nothing, are generally handed over to the general practitioner to shepherd to the grave, and it is well that he should be alive to the fact that for many of these cases he has in X-rays a powerful agent for the relief of distressing symptoms. In some cases treatment by X-rays can be reinforced and aided by the introduction of radium-tubes into the substance of a growth.

(3) Prophylactic—an attempt to prevent the recurrence of malignant disease. After operation the line of scar and the lymphatic gland area

draining the affected part are thoroughly irradiated at regular intervals with powerful doses of X-rays, with a view to destroying, while in the latent condition, any cells already affected by disease. This treatment is now almost a matter of routine after operation in certain types of malignant disease, and the results are encouraging. The methods of treatment will be dealt with fully later on. It is enough to say here that X-rays already play an important part in the treatment of disease and that their field of usefulness appears to be increasing.

The Importance of Rest, Proper Diet, Fresh Air, and Suitable Surroundings.—When a patient is undergoing a course of X-ray treatment for any condition there are several points on which it behoves the general practitioner to give careful directions.

The first of these is the question of *Rest.* While a patient is having treatment it is very important that as much rest should be taken as possible. The effect of treatment is often negatived by the fact that the patient tries to crowd it into an already full day, and has to hurry before and afterwards to make up for lost time. The day of treatment should also be a day of rest. The patient should return quietly home and spend some hours resting in the recumbent position, preferably in the open air, if the treatment is to have its full beneficial effect. This course is especially to be observed in such complaints as goitre and fibroid of the uterus. In the latter condition, when heavy dosage is employed, it is imperative that the patient should rest.

Patients who are sent for X-ray treatment, not diagnosis, and whose treatment is likely to take some time, such as in cases of uterine fibroid, should be warned that they may feel a little faint during or at the end of treatment. This is probably due to the charging of the atmosphere with ozone from the continuous running of the tube. There is nothing to be alarmed at, and the symptoms yield easily to a whiff of strong smelling-salts or eau de Cologne.

Diet.—Then, again, the question of diet is very important. The diet should be very generous, with abundance of flesh-forming food. Iron and arsenic tonics are valuable, as are also all foods which improve the quality of the blood.

Lastly, freedom from worry and overwork are very essential. Any mental strain militates greatly against the beneficial effects of treatment. In short, all patients undergoing a course of X-ray treatment should be advised to give up their usual life and occupation for a time, and devote themselves to living a life which shall assist the effect of the treatment and not antagonise it.

ACTION OF X-RAYS ON THE TISSUES

The beam of rays generated by the X-ray tube is a heterogeneous one, consisting of rays of varying degrees of hardness and penetrative powers. This beam is permitted to play upon the part which it is desired to treat, and the particular type of ray required for the particular case is directed on the lesion. Thus treatment of disease in deep-seated organs requires the hardest quality of ray, and the softer rays are absorbed by filters, chiefly of aluminium, placed over the port of entry. Superficial lesions of the skin are treated by the softer, less penetrating rays. The skin surrounding the area requiring treatment is carefully protected from all rays by some substance, such as lead or rubber, which is impermeable to X-rays.

The action of radiations upon normal tissues is primarily a stimulating one, causing a congestion of the exposed area. This congestion is followed in course of time by an increased formation of fibrous tissue, and, if exposure is pressed, the action of the rays becomes a caustic one, setting up an acute inflammation which may go on to necrosis and sloughing.

The degree to which treatment is pressed will vary with the effect required. Each case must be treated on its own merits, and the type of treatment adopted will lie in the hands of the expert radiologist. Upon his judgment and skill in adjusting the dose and filtration will depend in great measure the success of the treatment.

When the exposure has been correctly estimated the inflammation will subside after a given time, and the more deeply situated tissues will share in the reaction in a diminishing ratio according to their depth from the surface.

The inflammatory stage is accompanied by a migration of leucocytes and an invasion of small round cells. With the subsidence of this begins the formation of connective tissue, and this newly formed tissue, with its capillary blood-vessels, may surround individual cells or areas of cells. Where contraction of the fibrous tissue begins, the blood supply to these areas may be cut off, and according to the rate at which this constriction proceeds so will the ensuing tissue change.

If the occlusion of the blood-vessel to an area is rapid, necrosis and sloughing soon follow, but if it is more gradual atrophic changes are noticed.

This power of radiations to cause necrosis and sloughing is often made use of in therapy where necrosis of a mass is desired, in the hope that, when the tissues have sloughed, normal cells will fill in the resulting ulcer. This form of treatment is often resorted to in cases of malignant disease.

In addition to the local action of radiations upon cells there is reason to think that there is also a general action resulting in an improvement in the whole condition and vitality of the patient. There is often a gain in weight, an improvement in colour, and an improvement in the condition of the blood. Full advantage should be taken of this general effect of radiation treatment, and the patient should be instructed to do everything possible to assist in general management. Generous diet, tonics, rest, and freedom from worry, and plenty of fresh air, are very important points to which it is the business of the general practitioner in charge of the case to attend.

It is now thought that in addition to the direct effect of the radiations upon a lesion there is also an effect due to secondary radiations. These secondary radiations are given off by metal-containing compounds circulating in the blood stream as it passes through the tissues where these compounds are bombarded by the beam of X-rays.

Metals, such as iron and arsenic, are known to have a definite secondary radiation output, and there is very little doubt that when these or similar substances are circulating in colloidal form in the blood stream they can produce secondary radiations of therapeutic value when subjected to a penetrating beam of X-rays. The limit of their power would seem to be the capacity of the blood to hold these substances. Much important research work is being done now on this point, and though the subject is as yet hypothetical, it may well be that in the near future the radiation treatment of deep-seated lesions may be preceded by the injection of the lesion itself and the surrounding tissues with colloidal preparations of suitable metals so as to intensify this secondary radiation effect to the utmost.

Diseases of the Skin

X-rays when applied to the skin cause, after a given time, an erythema, which manifests itself by slight reddening. This passes off after a few days. If the dose is excessive, severe dermatitis and burns may result. Microscopically a section of skin treated with X-rays shows an infiltration of leucocytes in the cornual layer. After prolonged treatment the squamous cells are found to be degenerated and to have lost the nuclei. The atrophic changes are in proportion to the extent and duration of the treatment.

In skin surfaces covered with hair complete depilation follows, but if the dose has been correctly estimated the follicles are not destroyed and the hair grows again. This is taken advantage of in the X-ray treatment for ringworm. If ulceration ensues, the follicles are completely destroyed and permanent alopecia results.

Acute dermatitis may only partially subside and a condition of sub-acute inflammation persist, which is very troublesome and difficult to deal with. It may persist for years and finally take on a malignant character. Occasionally X-ray treatment of the skin is followed by late manifestations, coming on months or even years after the treatment. Late ulceration and telangiectasis are the usual forms.

X-ray treatment is of much service in cases of :

Eczema.—Chronic and sub-acute cases which have resisted all other forms of treatment will often yield to X-rays. Acute cases should not be treated. It is important that the general practitioner should remember that before sending a patient for X-ray treatment all local treatment by drugs, lotions, ointments, etc., *which contain iodine or metallic bases* must be discontinued and time allowed for their removal from the skin. Internal tonic treatment may be continued. After treatment, if specific directions are not given by the radiologist, the parts should be dusted with a powder of zinc, oxide, and starch.

Psoriasis.—When this disease occurs in very large and persistent patches, X-ray treatment should always be tried. It is often very successful and is a much more agreeable form of treatment to the patient than ointments, especially when large surfaces have to be covered.

Prurigo.—In this very distressing complaint X-rays sometimes give more relief than any other form of treatment, and should be tried.

Ringworm.—X-rays have now been employed for more than ten years in the treatment of this complaint. The technique is involved and is the province of the radiologist. Certain points should be borne in mind by the general practitioner:

(1) Full details must be furnished to the radiologist as to previous treatment, which must be discontinued for at least a week before X-rays are applied.

(2) Patients with any septic condition of the scalp must not be sent until this is cured.

(3) The scalp must be thoroughly shaved before the patient is sent for treatment.

(4) After treatment, the scalp must be washed two or three times a week and a skull-cap of linen be worn. A mild antiseptic ointment should be used.

On no account should active counter-irritants be employed after X-rays have been used. The use of strong iodine and mercurial preparations may account for a number of the severe reactions following upon treatment. Permanent alopecia may be the result.

(5) The general practitioner should never omit to warn the patient or relatives that the danger of permanent alopecia as a result of treatment does exist. Some persons react much more violently than others to X-rays, and now and again a case occurs where, in spite of every precaution, there is a violent reaction to an apparently mild dose of rays. In this connection it is well to remember that children with fair hair respond more readily than those with dark hair.

Lupus.—Lupus is very amenable to X-rays and excellent results are obtained, quite as good as those got with Finsen light, and the treatment is shorter and less tedious. The patient should be kept under observation for a considerable length of time.

Pustular Acne, which proves very intractable to ordinary treatment, will often clear up when a few X-ray exposures are given. This treatment, when combined with injections of vaccine, is very successful. Many patients suffer much inconvenience from this condition, and the general practitioner should be aware of this method of giving relief.

ENLARGED LYMPHATIC GLANDS

The treatment of enlarged lymphatic glands by radiations, both X-rays and radium, is one of the important advances in medicine of recent years. In large towns where well-equipped and up-to-date hospitals abound this treatment is in constant use, but it is not yet as much appreciated by the general practitioner as it should be. The possibilities of treatment are very far-reaching, and, as technique improves, new fields of usefulness are constantly being opened up.

X-ray treatment offers a good alternative to operation in cases where, from size, wideness of distribution, or the general condition of the patient, operative measures are contra-indicated. It is seldom that an effect, even if it be only a temporary one, cannot be produced with a radiation of suitable hardness, and relief from distressing symptoms obtained. The treatment may be classified as—(*a*) curative, (*b*) preparatory to operative, (*c*) prophylactic and palliative, according to the effect it is hoped to produce.

The conditions in which radiations have been found to be helpful are: Simple chronic inflammations, tuberculous glands, lymphadenomatous glands, enlarged glands in blood diseases, such as lymphatic leuchæmia, enlarged glands due to malignant disease.

Patients suffering from **inflammatory glands** are not usually sent for X-ray treatment because the glands generally subside when the exciting cause is removed, but occasionally the condition becomes chronic, or suppuration has occurred and a discharging sinus persists. Thorough irradiation often exercises a marked beneficial effect.

Tubercular Glands.—If treatment is begun early and continued over a sufficient length of time, very good results are often obtained and operation may be avoided altogether. Treatment should be begun before there is any breaking down of the gland, and should be accompanied by general suitable treatment, with tonics and abundance of fresh air and good food. It is the treatment of election in cases where operative measures cannot be taken because of the exigencies of the case, and should be vigorously pushed.

Lymphadenomatous Glands.—These are very amenable to treatment but are prone to recur. They may entirely disappear, but after some time will reappear, or a fresh group take their place. Treatment should be very thorough and systematic, kept up for a long time, and a dose given at intervals of a few weeks for many months after regular treatment has ceased. Lymphadenoma is not a disease in which the prognosis is good. Most cases ultimately recur and end fatally, but it may be said that radiation treatment so far holds out better prospects than any other. The special treatment should be combined with every form of tonic and general treatment, especially iron and arsenic.

Malignant Glands.—(1) *Carcinomatous glands* are secondary to a primary condition elsewhere. These glands usually follow one particular chain of lymphatic distribution. They are somewhat slow of growth and ulcerate only late in the disease. Treatment is, as a rule, palliative and prophylactic. Recurrences can often be checked and sometimes prevented by X-rays. Sometimes a mass of glands, so large as to be impossible of removal, if subjected to vigorous X-ray treatment can be reduced to an operable size. This last point is an important one to the general practitioner. In the case of a patient incurably ill, but suffering much distress from glandular involvement, a measure of relief can almost certainly be obtained from radiations.

(2) *Sarcomatous Glands.*—The prognosis is not good. The glands may be the seat of a primary lympho-sarcoma or secondary to a primary growth near by. These glands respond well to radiations—particularly to radium rays—for a time. Treatment should be vigorously pressed after operation. A combined X-ray and radium treatment often gives excellent temporary results.

Diseases of the Blood and Ductless Glands

Radiations have a definite effect upon lymphatic tissue, upon the constituents of the blood, and upon the substances circulating in the lymph. Heavy or prolonged treatment causes a decrease in the number of white cells, and differential counts should be made from time to time.

Hodgkin's disease and leuchæmia—both the spleno-medullary and the lymphatic—respond well to treatment, and if treated in the early stages the progress of the disease may be arrested, usually for long periods, and sometimes there may be actual cure. It is probable that the best results are obtained when radiation treatment is combined with internal medication by iron and arsenic so that the secondary radiation effect may be obtained. In Hodgkin's disease a marked diminution in the enlarged glands may be obtained. In leuchæmia the clinical symptoms and the blood count must be closely watched, as very rapid changes in the blood may be induced, with a reduction of white cells below the normal and a marked increase in myeloblasts. This calls for a suspension of treatment, or fatal results may ensue.

CHRONIC SINUSES AND BONE DISEASE

The X-ray treatment of chronic sinuses has been largely developed in dealing with war injuries. The difficulty of inducing these sinuses—the sequelæ of very septic wounds—to heal is very great. It has been found that radiations, both X-rays and radium, have a stimulating effect on the tissues, even when there is dead bone involved. Treatment hastens the pathological process and lessens discharge. It may also be tried in chronic tubercular suppuration, for instance in abscess of the hip or psoas abscess, or in cases of chronic fistula. Sometimes the sinus is filled with bismuth paste and then thoroughly irradiated so as to get the full secondary radiation effect.

RODENT ULCER

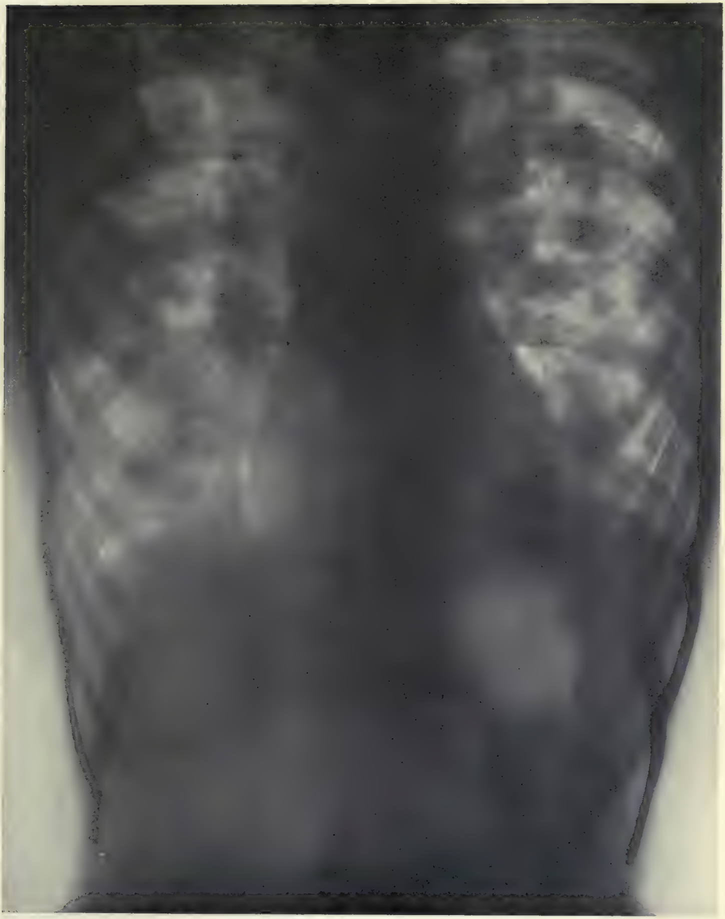
This slow-growing but very intractable condition is now very frequently treated with X-rays, or X-rays combined with radium, or by radium alone, in preference to operation. The tendency is of course for the disease to recur, and treatment should be kept up at long intervals for months after a cure seems to have been effected. If the case can be sent for treatment before bone or cartilage are involved the chances of complete cure are much greater, as when these have been eroded the process of healing is much slower.

The fact that rodent ulcer so often attacks the face, and especially a spot where there is an angle, such as the junction of the nostril and cheek, or the orbit, or the junction of the skin and mucous membrane at the mouth, is an argument in favour of X-ray rather than operative treatment, as the scar resulting is pliable and there is no further loss of tissue with resulting deformity. X-rays may be used after operation to reduce the contraction following upon cheloid.

There is no stereotyped time or type of treatment; each case must be judged on its own merits and the dosage calculated by the radiologist. When the literature of the ray treatment of rodent ulcer is considered, the conclusion is almost forced upon one that treatment by X-rays and radium offer the patient, so far, the greatest possibilities of success with the least measure of deformity from scar, and that in the cases where a cure has not been effected, the failure is due to a faulty selection of the appropriate ray and an incorrect appreciation of the necessary dosage, rather than to the agent itself. It must always be remembered that the beam of X or radium rays is a composite and heterogeneous one, made up of many rays of differing quality of hardness and penetration. The particular hardness of ray which suits the particular lesion and acts most favourably on the surrounding cells must be found before the acme of benefit can be derived, and then allowed to play on the parts for just the right length of time ; the assumption may fairly be made that in the cases where a lasting cure has been effected, this accurate co-ordination has been accomplished, and that in less favourable cases there has been some error. Research work on these points is continually being carried out, and there is reason to hope that as time goes on the percentage of successes will steadily increase. Meanwhile it is well that the general practitioner should fully grasp the fact that the ray treatment of rodent ulcer, and indeed of all pathological conditions, is a complex matter calling for a considerable degree of experience, both in general medicine and in the handling of the agents employed, and that patients should only be sent for treatment to an experienced radiologist. Otherwise not only will the patient derive little or no benefit, but discredit will be brought on the method employed.

Malignant Disease

Of late years the treatment of malignant diseases by radiations has become almost a matter of routine in large well-equipped hospitals,



THORAX.

Showing secondary carcinoma of both lungs and pleuræ.
(Primary lesion in the breast.)

and is daily becoming more general in private practice.

Removal by operation is still the treatment *par excellence* in every case where it is practicable, but treatment by radiations at some stage in the history of the disease is now an accepted routine and not a tentative experiment.

The most usual form of treatment is prophylactic, after operation for removal of the primary growth. As soon as possible after operation, the scar and a large area of skin and underlying tissues in the neighbourhood of the incision, as well as the area of lymphatic glands, are all thoroughly irradiated with the appropriate ray at suitable intervals extending over some weeks or months. This treatment is undertaken in the hope of destroying any infected cells that may have escaped removal by the knife, and of stimulating fibrosis around the mutilated area.

Sometimes, as mentioned before, a patient presents a large mass of growth, either primary or a glandular secondary growth, involving so much tissue as to be inoperable, which causes great discomfort from its size and pressure. It has been proved in several instances that vigorous radiation treatment, suitably applied, will so reduce the tumour as to render partial removal possible, and greatly relieve the discomfort of the patient.

Or again, in some cases of malignant disease, especially of the uterus and pelvic organs and of the rectum, where the disease cannot be removed and distressing local symptoms such as pain, discharge, and sloughing are present, radiation treatment will sometimes arrest the local manifestations and give the greatest relief. This use of radiations should be carefully noted by the general practitioner, as patients suffering in this way are usually in his charge, and it is thus now in his power to procure them an appreciable measure of comfort and temporary ease.

Where removal by operation is possible this line of treatment, rather than radiation, should always be recommended to a patient as the primary one. It is much more rational to remove the growth and then irradiate the site, than to try to affect, even with a very hard and penetrating ray, dense thick masses of malignant tissue. After removal, even if recurrence takes place, the skin can often be kept intact and the patient saved from sloughing and ulceration.

Sarcomatous growths are very malignant and recurrence usually takes place, often internally and in parts remote from the primary growth. In carcinoma, save in young people, the prophylaxis is more hopeful. It is now fairly established that if operation has been undertaken at an early stage, and systematic irradiation treatment is carried out, recurrences can sometimes be prevented, the remnants of cancer left in the wound disappearing under the action of the rays.

Cases of epitheliomata sometimes yield to X-rays, but radium is the remedy which should be chosen in the majority of cases. Often a judicious combination of X-rays and radium rays will produce the best results. Cases that appear to have healed should be kept under observation for some years and come up periodically for inspection.

This book being written for the general practitioner, in whose charge, for the greater part of their treatment, are the great majority of patients suffering from malignant diseases, it will be well to say a word of caution as to radium rays being a "specific cure" for cancer. I cannot do better than quote from the second edition of *Radiotherapeutics* (Robert Knox) on this point. This writer having had the direction of all the radium and X-ray therapeutic work carried out at the Cancer Hospital, Fulham Road, London, during the past six or seven years, is well qualified to express an opinion on this important point. He says: "It is not out of place here to enter a strong protest against the indiscriminate use of radium by experts and non-experts, the practice of which has only resulted in bringing discredit upon the experimenters, and has greatly hindered a proper appreciation of radium as a curative agent. The time has long passed when this practice was excusable. In the interests of the public, which is largely guided by its medical men on these matters, it should be clearly understood that radium has distinct limitations in the treatment of disease, and particularly in the treatment of cancer, where it has been so liberally exploited. No treatment by radium should be undertaken unless the matter has been thoroughly gone into in consultation with surgical and radium experts. The possibilities of relief or cure should be thoroughly discussed. It is not sufficient to undertake the treatment of a growth by making an incision into it and inserting a tube of radium or emanation. More than that is required, and a thorough knowledge of the action of the particular quantity of radium used is necessary." Again: "That the radiations from radium and X-rays exercise a marked influence upon tissues and tissue metabolism is an admitted fact, but the nature of this influence is still imperfectly understood, and must necessarily remain so until we know more about the biological effects induced in the tissues by these radiations. It has been claimed that radium possesses a 'selective action' on cancer cells. While admitting that it undoubtedly appears to act on such cells, the word 'selective' is badly used. Colwell and Russ particularly direct attention to the selective absorption of radiations by the tissues. This is applicable to all forms of radiation, and has no special reference to radium. The term appears to be a more rational one than that of 'selective action,' as, in using the latter, we are definitely claiming that radium possesses a selective action upon cellular structure, and particularly upon the cancer cell. Radium exercises an action on all living cells in a varying degree according to the resistance of the particular cell in question. Thus, young, actively growing cells are more readily influenced than mature cells. The cells of a new growth approximate in structure and power of resistance to the actively growing cells of a tissue. In this way it is conceivable that the cancer cell is influenced, should it at the time of exposure be comparatively early in its life cycle. Should the cancer cells be of a stronger or more vigorous type, it is conceivable that the action of the radium may be stimulating, and instead of a decrease in vigour of a particular cell we may find an increase of activity, and a consequent increase in the size of a tumour. It is a fact that some cases of cancer increase in size at a quicker rate after radium has been applied. Some types of cancer are more amenable to radium treatment than others."

NON-MALIGNANT DISEASES OF THE PELVIC ORGANS

Treatment by X-rays and radium, singly or combined, has during the past few years come very rapidly to the fore in two of the most important diseases affecting the pelvic organs—namely, fibroid tumour of the uterus and carcinoma of the uterus and vagina.

Fibroid Tumour.—The treatment of this condition by X-rays was first carried out in a systematic manner by Continental radiologists, though at the same time a good deal of work was being done on similar lines in this country and in America. Several techniques have been worked out for the treatment, and it can now be carried out in a satisfactory manner in a number of large centres. The method should only be used by an experienced radiologist and in collaboration with a gynæcologist. Not every form of fibroid tumour is suitable for this treatment. The interstitial form, where there is marked hæmorrhage at the period with abundant clots, is the suitable type. Fibroids, where there is calcification, or necrobiotic change, or where there is any suspicion of malignancy or any complicating septic condition, such as salpingitis or pelvic peritonitis, should not be treated by X-rays. In all cases the opinion of a gynæcologist should be obtained before treatment is undertaken, in order that the correct diagnosis may be established.

When the fibroid tumour is of the suitable type this treatment offers an alternative to operation which is very acceptable to many patients, particularly to those who, anæmic and debilitated by loss of blood, are not in a fit state to undergo a major operation, and to those to whom the idea of mutilation is very repugnant.

The treatment is simple for the patient, involves no elaborate preparation, obviates anæsthetics and weeks in a nursing home, and it may now be confidently asserted that the results are very good. The percentage of failures is already very small, and as the technique is perfected will become smaller still. The slight malaise due to the treatment, which is sometimes experienced by the patient, is very transient, yielding to a day or two's rest and quiet.

The treatment is usually pressed until the menopause is brought on, and in the majority of cases the tumour is markedly reduced in size as well, but the arrest of hæmorrhage and the recovery of the patient from the consequent anæmia are the important points. It may safely be said that, given the suitable type of fibroid tumour, no treatment gives as good results with as little disturbance to the patient as that by X-rays. It is one of the important advances in therapy of recent years and may be confidently recommended.

Menorrhagia at Climacteric.—Ray therapy is also of much service in menorrhagias of other cause than fibroid tumour. Thus severe hæmorrhage occurring at the climacteric yields readily to X-rays, and this treatment should be advised when other methods fail to give relief. In very intractable cases of dysmenorrhea also, when all other methods of treatment fail to give relief, and when the patient's life is really rendered a burden to her by reason of the ever-recurring suffering and disability, sterilisation, permanent or temporary, can be brought about by X-rays, and is a treatment to be carefully considered. In the majority of these cases the dysmenorrhea is due to want of proper development of the uterine muscle and the adnexa, and operative measures fail to give any relief. These cases are usually sterile, and treatment by X-rays is therefore not contra-indicated. It should, however, only be undertaken after consultation with an experienced gynæcologist.

Carcinoma of the Uterus.—Radium rays are specially useful in the treatment of this condition, and occasionally the combined use of radium and X-rays. In inoperable cases where the local condition is distressing, this treatment is now being employed very frequently and satisfactory results are obtained. The treatment is of course palliative, and arrest of secondary growths in adjacent parts and the lymphatic glands should not be expected, but with the employment of a suitable technique the condition of the cervix can be greatly improved, ulceration arrested, discharge lessened or dried up, and the patient restored temporarily to a condition of comfort. Treatment by penetrating X-rays can then be pressed with a view to influencing the secondary growths in deep-seated tissues.

This method of treatment should be noted by the general practitioner, under whose care the patient suffering from inoperable carcinoma of the uterus usually is. It offers an appreciable measure of relief unaccompanied by the inconveniences of frequent partial operations. The treatment should, however, only be carried out by an experienced radiologist in collaboration with a gynæcologist.

Exophthalmic Goitre.—A great deal of research work is being carried on in regard to this complaint. The origin and cause of the disease are still obscure, and the treatment is still largely empirical. Drugs are merely palliative in their effects. Much can be done by prolonged rest, especially in the open air, and careful dieting with strict attention to intestinal antisepsis. In cases where there is marked enlargement of the thyroid gland, it has been found that treatment by X-rays or radium, or both, is often very effective in reducing the size of the tumour and slowing down the pulse. The exophthalmos also usually disappears. The tremor and cardiac symptoms yield more slowly, but soon become much less distressing.

The results from radiation treatment are so good as to warrant a trial of this form of treatment in all cases where thyroid enlargement and exophthalmos exist. So far very little literature is available as to the effects of radiations in cases of the disease where these symptoms are not prominent.

The allied conditions of hyperthyroidism and "irritable heart," so often met with at present in soldiers as a result of war-strain, are also very amenable for the most part to radiation treatment. It should be remembered that severe and prolonged treatment may result in marked telangiectasis, and on this account every precaution should be taken to protect the skin from superficial reactions.

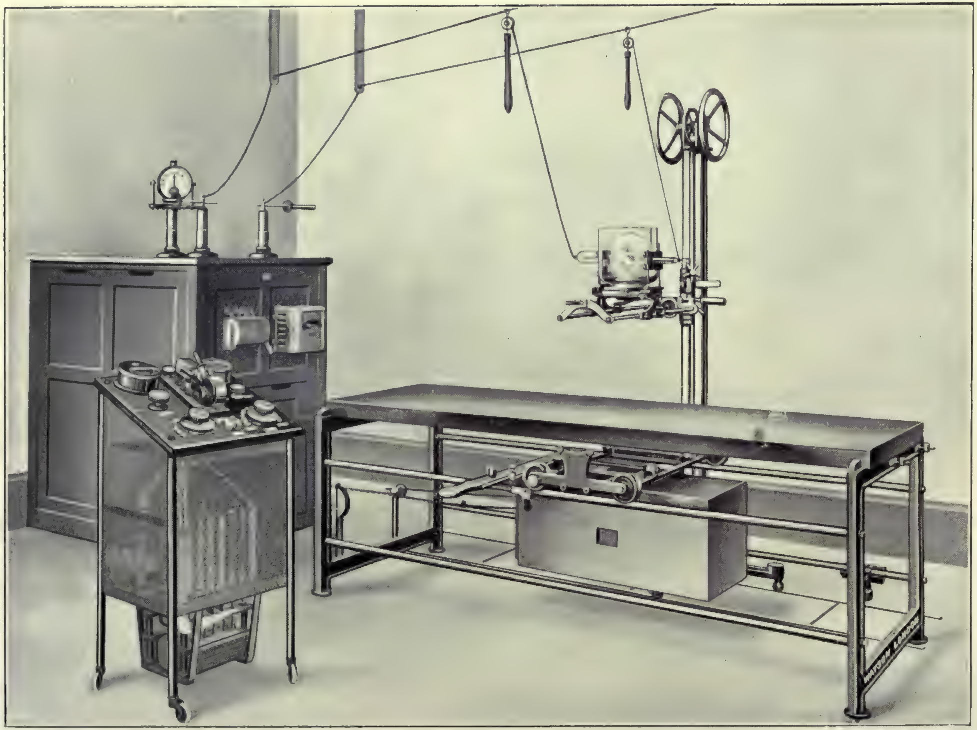
Hyperidrosis.—This complaint, though not dangerous, is often a source of great annoyance to the sufferers, and is very intractable to most lines of treatment. It does, however, yield to X-ray treatment when the dosage is correctly estimated, and by this means may be readily and permanently cured. The general practitioner should be aware of this and may recommend the treatment without hesitation. Details of technique are of course left to the radiologist, but it may be stated that it is not necessary and is not desirable that the treatment should be pushed till all sweating is entirely prevented. The aim should be to treat until what may be described as the normal condition is arrived at. Telangiectasis sometimes follows very energetic treatment.

Hypertrichosis. — X-ray treatment is often resorted to for the removal of superfluous hairs, and if the dosage has been correctly estimated it is very successful. Telangiectasis is rather apt to follow treatment, and it is very important that the treatment should only be given by an experienced radiologist. In such hands, however, X-rays offer advantages over electrolysis in that there is no scarring.

Treatment of Scar Tissue.—It has long been known that cheloid scars can be greatly improved by X-ray treatment. They are rendered thinner, more plastic and less disfiguring, and greater freedom of movement is afforded to the underlying tissues.

During the past few years the radiation treatment of scars has been greatly developed in dealing with the results of war injuries, and very remarkable improvements have been effected both in this country and on the Continent. In a work of this character details of treatment need not be dwelt on, but bad cases of scar resulting from extensive burns are fairly common in general practice, and it is well that the general practitioner should be aware that radiations can do much to improve the condition of the scar and lessen the deformity. Treatment should be thorough and may require to be continued over long periods of time.

PLATE XXIX.



Watson & Sons, Ltd.

A MODERN X-RAY OUTFIT.

PART II

THE PRODUCTION OF X-RAYS AND INSTRUMENTATION

By Robert Knox, M.D., C.M., M.R.C.S., L.R.C.P.

CHAPTER V

THE DISCOVERY AND DEVELOPMENT OF X-RAYS

In the autumn of 1895 Professor Röntgen of Würzburg discovered accidentally the rays which are now widely known as Röntgen or X-rays. During a research for invisible light rays he found that when a low-pressure discharge tube was active a fluorescent screen lying about nine feet away shone out brightly. The cause of the fluorescence was traced to radiations coming from the active tube, and Röntgen designated the radiations "X-rays." Further investigation showed that these rays possessed the property of penetrating substances opaque to ordinary light. The degree of penetration was found to have a direct proportion to the density of the substances experimented with. In this apparently simple manner was discovered one of the most remarkable of the developments in Physics, which has been of extraordinary value in research work, and, in the hands of the medical profession, has rendered inestimable services to mankind. It was soon found that X-rays acted upon a photographic plate, that they possessed the power of ionising or imparting temporary electrical conductivity to gases. Of these properties it will be necessary to speak later in this work. The recognition of these two properties led, after a considerable amount of research, to the initial work which rendered possible the development of the present-day technique in Radiography and Radiotherapy. In this way one of the greatest scientific discoveries of any time resulted in the gradual building up of a new science now always associated with the name of Röntgen, though the actual discovery had been led up to by the work of Sir William Crookes and others.

In order to enable the beginner to grasp the value of this development it will be necessary to consider briefly the production of X-rays, and the accessory apparatus which has become almost essential to the execution of the radiographic and therapeutic work now carried on all over the civilised world, and to describe the manner in which the new agent may be used in practical medicine.

THE PART PLAYED BY ELECTRICITY IN THE PRODUCTION OF X-RAYS

The steps in the process are simple so long as we remember that electricity plays an important part in the production of cathode and X-rays, and that it is essential that the low-tension current be transformed into a current of high tension before the X-ray tube can be excited to produce the X-rays.

The source of low-tension current is immaterial so long as it is of sufficient voltage to actuate the induction coil.

For convenience, the supply of current is obtained from the electric light mains when these are available. Two forms of current are available in this way—namely, the continuous and the alternating; the former is the more convenient for our purpose, though it is possible to utilise the latter; when this is done it may be well to transform the alternating current into a continuous one, when an induction coil is used as a means of producing the high-tension current necessary for the action of an X-ray tube, or to use a special high-tension, step-up transformer.

Practical Points of Value when installing an X-ray Outfit

The important points to bear in mind when determining to instal an X-ray apparatus are (1) the nature of the current, *i.e.* continuous or alternating; if the latter, the periodicity of the current should be stated: (2) the voltage. These are important points for the consideration of the electrical engineer or manufacturer who has to instal the apparatus.

Source of Supply of Electrical Current other than from Electric Mains

Should the electric mains be not available it is still possible to provide a current of electricity for our X-ray apparatus. The simplest, though not the most convenient, is to have a number of electrical units, or accumulators, which will be sufficient for our purpose. This method is utilised for the purpose of supplying the current for portable outfits. These are not very satisfactory unless a large number of cells can be provided, and the question of transport has to be thought of.

The next best method is to have a small generating set, generally driven by a petrol engine, in which a motor generator is provided for the supply of the electrical current.

An apparatus of this type can be fitted into a motor-lorry, and a complete X-ray installation with dark room and accessories provided, so that the radiologist may go anywhere and do good-class work. For portable work this "mobile unit" is of the greatest possible value, and several of them have been in use at the Front during the War.

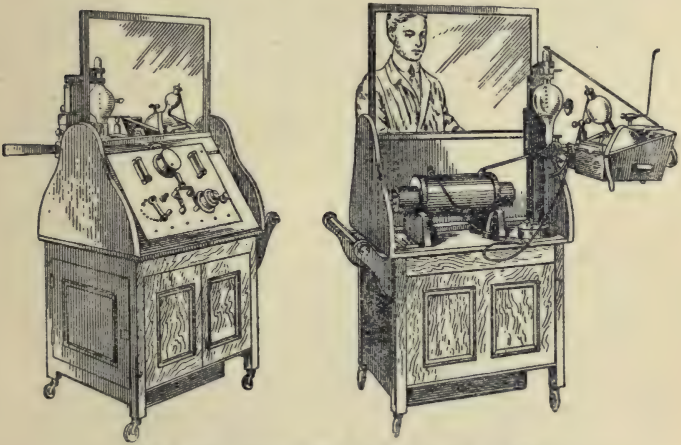


Fig. 17.—Illustration of a portable outfit.
(Reproduced by the courtesy of Messrs. Watson & Sons, Ltd.)

The employment of electricity for the production of X-rays necessitates the use of intermediate apparatus; as the low-tension current if connected direct to the tube will not actuate the bulb, it is necessary to transform the low tension into a current of high tension.

It will be well to first describe the tube with which Röntgen discovered the X-rays, and trace the development of the present-day tube from it. A short description of the methods employed for the energising of the tube, and also of the accessory apparatus, will be given.

The Vacuum Tube or X-ray Bulb

The vacuum tube with which Röntgen made his discovery in 1895 was pear-shaped, with a flat disc cathode mounted at its narrow end. The anode was in a small side tube.

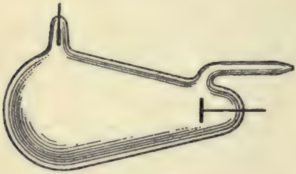


Fig. 18.
Röntgen's vacuum tube.

A later development was the focus tube by Jackson, who was the first to employ a curved cathode. He mounted the platinum target at an angle of 45° to the rays. This new tube was a great advance on its predecessors, and has been the model upon which practically all the tubes, up to the advent of the Coolidge tube, were based.

The details of Jackson's tube are here given in diagram.

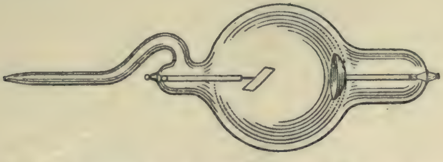


FIG. 19.—Jackson's first focus tube employing focussed cathode rays.

The modern X-ray bulb is constructed on the lines first indicated by Jackson. There are a number of accessory parts, but the essentials are still the same.

Description of an X-ray Tube.—The simplest form of X-ray tube consists of a thin blown-out glass bulb containing certain parts essential for the production of the rays. This bulb is fixed to a pump and exhausted of air ; the degree of exhaustion exercises a great influence on the penetrative power of the radiations emitted from it when in action. A diagram will explain its construction and the essential parts ; the most complete type of tube known at present is that introduced by Dr. Coolidge.

The essential parts of an X-ray tube are :

(*a*) Exhausted glass bulb.
(*b*) Anode terminal.
(*c*) Cathode terminal.
(*d*) Anti-cathode.

The accessory parts are:

(*a*) Regulating chamber with regulating rod.

(*b*) Cooling device.

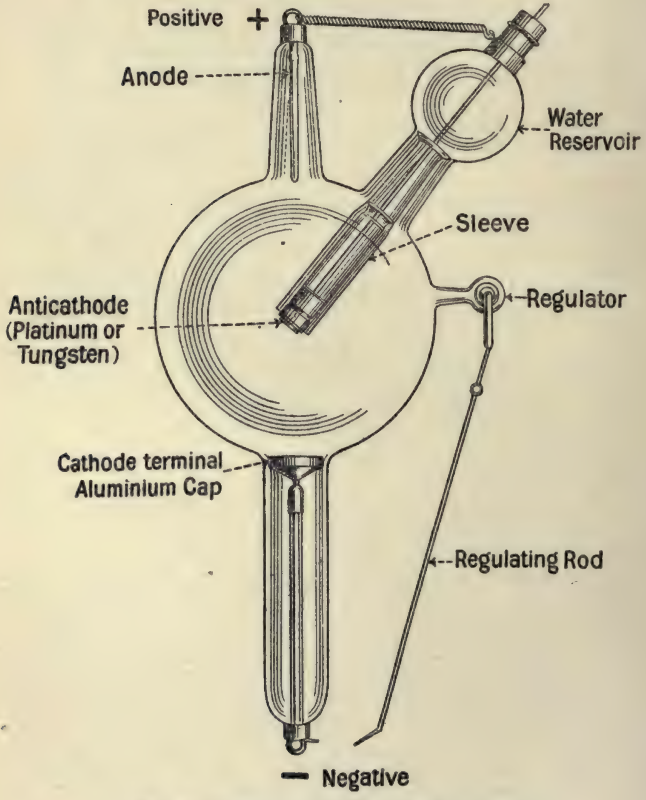


FIG. 20.—Diagram of a rapid X-ray tube.

A cooling device is necessary in the ordinary type of tube when large currents are passed through it, or when it is used for long exposures in treatment; the Coolidge tube is not so dependent upon cooling as the ordinary gas tube, but even it may require to have a current of air circulating round the bulb when it is used for deep therapy.

DEVELOPMENTS IN THE DESIGNS OF X-RAY TUBES

There are a number of modifications of the X-ray tube. Of these the one most commonly in use is that introduced by Dr. Coolidge. It is what has become known as a "hot cathode" tube, in contradistinction to the better known "gas tube." To clearly define the difference between these two types it will be well to describe shortly the principles upon which the

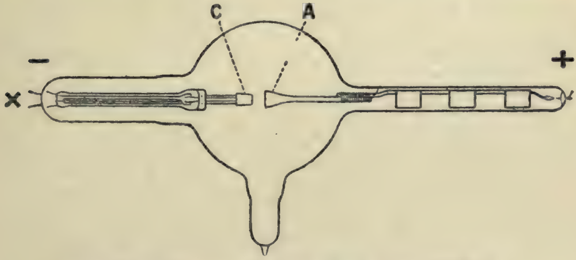


FIG. 21.—Diagram of a Coolidge tube (B.T.H.).

A, Anti-cathode.
C, Cathode.
+, Positive terminal.
−, Negative terminal.
×, Connections to heating circuit

Coolidge tube are based, since this type of tube is likely to displace all others.

This tube was invented by D. D. Coolidge; it is devised to be entirely free of gas, and has a vacuum 1000 times greater than the ordinary tube, so that it is impossible to pass a current through it in the ordinary way even with the most powerful apparatus. The anti-cathode is constructed of tungsten, and the cathode, instead of being an aluminium cup-shaped electrode, consists of a spiral of tungsten wire surrounded by a sleeve of molybdenum. The function of the latter is to focus the cathode stream. Connected to the cathode spiral is an auxiliary source of current, obtained from a small accumulator battery. This heats the metal, causing it to give off a stream of negatively-charged electrons which are projected on to the anti-cathode. It is important that the battery and all parts of the auxiliary circuit be well insulated from the earth, because it is in direct contact with the high-tension circuit.

The number of electrons freed from the anti-cathode is regulated by the degree of heating of the tungsten spiral; and the speed of the cathode stream, upon which depends the penetrating power of the X-rays, is regulated by increasing or diminishing the potential at the terminals of the tube.

It is claimed that this tube will give accuracy of adjustment, stability of hardness, possibility of duplication of results, unlimited life, great range of flexibility, absence of inverse radiation, and large output. The chief features seem to be that up to a certain limit any degree of hardness can be obtained, and any quantity of rays, and these two factors may be kept constant for indefinite periods. The most valuable advantage is that indicated by its great output for deep therapeutic work, and also for instantaneous radiography. There is a note of warning which it is well to put forward, and that is that this tube gives little or no visible sign of fluorescence, so that extra precautions must be taken; otherwise, owing to its much greater output, and the fact that the tube will continue to give a steady flow of radiation, a serious burn can be produced if careful measurement of the dose is not employed,

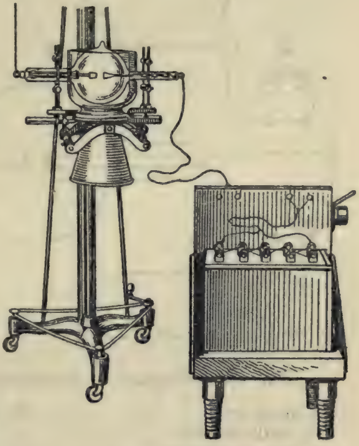


FIG. 22.—Complete Coolidge X-ray equipment in position. (B.T.H.)

whereas the ordinary form of tube cannot be continuously run with a heavy current. A tube designed by Lillienfeld is also constructed to work with a "hot" cathode. It is somewhat more complicated than the Coolidge tube.

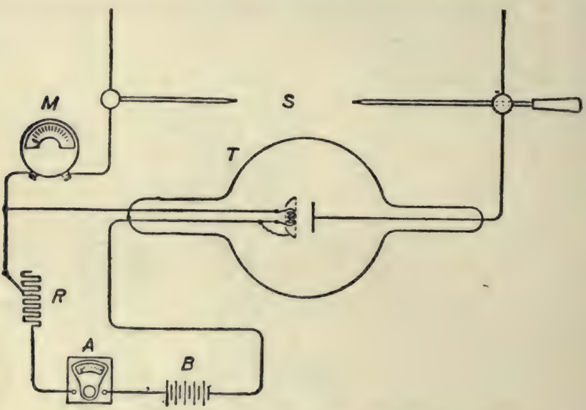


Fig. 23.—Diagram of connections for Coolidge tube.

S, Spark-gap.
M, Milliammeter.
B, Storage battery.
R, Rheostat for controlling current in the filament circuit.
A, Ammeter for measuring current in filament circuit.

Connections.—The accompanying illustration shows the tube properly connected to the storage battery and the terminals from the coil. *It must always be borne in mind that the entire battery circuit is brought to the full potential of the tube, and that it, therefore, has to be as thoroughly insulated* from the patient and the ground as has the tube itself.

The Battery.—A convenient size is a 5- or 6-cell (10- or 12-volt) 40 ampere-hour battery, and it will be found much more satisfactory if arrangements are made so that the battery can be connected, either every night or else whenever not in use during the day, to the charging circuit. In some cases it will be found convenient to have the battery stand on the floor, while in others it may advantageously be placed at a higher level on a shelf. In the latest models a small transformer takes the place of the battery for heating the spiral.

The small transformer unit is a great improvement upon the Accumulator set. It makes it possible to maintain a steady flow of radiations for long periods, and the operator is not then dependent upon fluctuations in the battery.

Explanation of Electrical Terms

The need for a more or less complete knowledge of electricity on the part of any one who intends to specialise in electricity in its applications to medicine is obvious. The use of electricity had been fairly extensive in the days before the discovery of X-rays, but then it was not expected that the practitioner should have more than a general knowledge of electricity and electrical apparatus.

The introduction of X-rays into practice has increased the need for a more extensive and accurate knowledge. The aim of this section on apparatus and technique will be to place in the hands of the practitioner sufficient elementary information to enable him to appreciate the descriptive matter relating to electrical apparatus used in medicine.

There are a number of electrical terms which are in common use, and these will be defined briefly. For more complete information the reader is referred to larger text-books dealing with these matters.

Amongst these are the ampere, the volt, and the ohm.

The ampere represents the *amount* of current, the volt the pressure, and the ohm the resistance.

In defining these terms, and in order to explain their use in electrical description, it is customary to take as an analogy to the flow of an electrical current the flow of a stream of water through a pipe. The amperes in this analogy represent the size in cross-section of the pipe, the volts the force or pressure of the water, and the ohms the friction. Take as an example a pressure or electro-motive force (in short, the E.M.F.) of one volt through or along a wire of one ohm, and the resistance will pass one ampere.

To express this in formula, let C = the number of amperes, E the number of volts, and B the resistance in ohms, then $C = \frac{E}{R}$.

The E.M.F. or voltage of the electric supply varies considerably in this country, the most common being 100, 200, and 240 volts.

The current required for X-ray work and many forms of electrical treatment is so small that the ampere is too large to express the current used, so it is necessary to divide the ampere into 1000 parts (milliamperes).

The high-tension current used for X-ray work is far in excess of anything that can be obtained from the electric mains, so it is necessary to transform the low-tension current into one of high-tension. This matter is dealt with fully later on; but in order to understand the principle it will be well to briefly describe the phenomenon known as "induction."

Suppose we take two parallel and adjacent wires AB and CD.

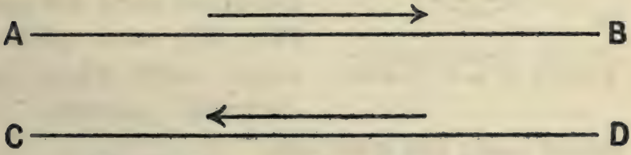


Fig. 24.—Diagram to illustrate path of current.

The Induction Coil

An electric current is made to pass along the wire to B. A corresponding current is induced in CD which, however, passes in the opposite direction to the current in AB—that is, from D to C. This induced current is momentary only, and only occurs when the current commences to flow along AB; if the current is passing continuously along the wire no further induced current appears in DC; but if the current along AB is interrupted another induced current passes along CD, but this time in the same direction as that in the originally interrupted current. Any change in the electrical current flowing in AB (the primary current) induces a momentary corresponding current in CD; this secondary current is in a direction which opposes the change in AB.

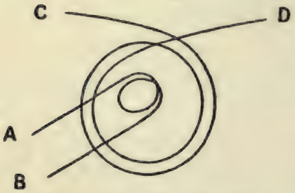


Fig. 25.—Spiral diagram to illustrate the path of current.

Now substitute for the two straight wires two spiral wires AB and CD. The same phenomena occur when an electrical current is passed along the spiral AB.

Suppose the secondary spiral contains twice the number of turns that the primary contains, then there will be induced in each turn of the secondary an E.M.F. corresponding to the E.M.F. of each primary turn.

The next important thing to realise is that the number of amperes has been correspondingly reduced by one-half.

The simple arrangement described is in fact an induction coil. There are of course many accessories, and each coil consists of a large number of primary and secondary turns of wire. The various parts which make up the induction coil will be briefly described, and, as far as is possible, a short description of the method of action given.

Having mastered the principle of induction the next step is to appreciate that there are several forms of apparatus which, when connected to a low-tension current circuit, will supply a current of high tension of a voltage sufficiently high to energise the X-ray tube.

These are grouped as follows: (1) influence machine; (2) induction coil; (3) step-up transformer.

(1) The **influence machine** is not generally used in this country, though in France and America it has found a certain amount of favour. Beyond mentioning it as a means of supply it need not be further discussed.

(2) **The Induction Coil.**—This important piece of apparatus requires careful description,

since it is the form of transformer which up to the present is most generally used. In America it has been largely displaced by the high-tension transformer, and in this country it is being slowly replaced by the same type of apparatus. It is, however, a very reliable type to use, and in its description it will be used to illustrate the method of transforming a low-tension current into one of high tension.

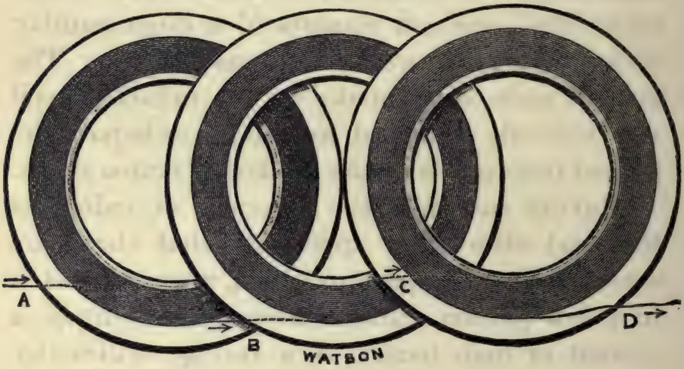


FIG. 26.—Jointless section windings of induction coil.

Description of an Induction Coil.—This consists of (1) the primary; (2) the secondary; (3) the core; (4) the condenser; (5) the interrupter.

Each has its own part in the action of the induction coil, and must be briefly described if the reader is to clearly understand the principles of the production of X-rays.

The *primary* consists of a number of turns of a thick copper wire wound round the core; it is usually wound in three layers, either as a single winding or, as is more common, as an adjustable winding, to allow of adaptability to meet the requirements of the coil.

The *secondary* consists of many thousand turns of fine wire wound round in a number of thin vertical sections.

The *core* consists of a bundle of thick iron rods or, in the case of a modern heavy induction coil, of many sheets of metal.

In construction the aim is to magnetise the core slowly (at "make"), and to demagnetise rapidly (at "break")—the spark length of the coil depending on the rapidity with which the core can be demagnetised, and the output of the coil upon the degree of magnetisation. We shall indicate later the part the core plays in the action of the coil.

The *condenser* consists of a number of sheets of tinfoil insulated from each other by sheets of waxed paper.

The functions of the condenser are chiefly three in number:

(1) To increase the slowness of the "make" and the suddenness of the "break."

(2) To suppress undue "sparking" and arcing in the interrupter.

(3) To retard the formation of induced currents in the primary, *i.e.* inverse current.

The *interrupter.* There are many ways in which interruption in the primary current may be produced; and for practical purposes a mercury interrupter will be described. The other form most commonly used is the Wehnelt, a most efficient interrupter and one which, if looked after carefully, works very satisfactorily. It is also one of the simplest forms.

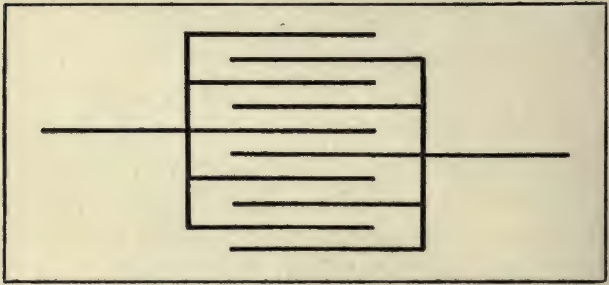


Fig. 27.—Diagram of a condenser.
(By the courtesy of Messrs. Watson & Sons, Ltd.)

"A Condenser consists of a number of sheets of tinfoil separated from each other by means of wax paper. The paper having greater dimensions than the tinfoil completely insulates one piece from the next. First of all, a sheet of thoroughly impregnated paper is placed down upon a flat surface, then a sheet of tinfoil is mounted in the centre of this, having a lug pointing to the left, then another sheet of paper and a sheet of tinfoil with a lug pointing to the right. The tinfoil is placed alternately left and right, and all the left-hand lugs are joined together and all the right-hand lugs joined together. It will be seen quite clearly that although every other sheet of tinfoil is connected on both sides of the Condenser there is no connection with the left-hand lugs and the right-hand lugs. When the Condenser is completely piled it is subjected to compression and heat to exclude all air and at the same time to seal all the tinfoil and paper into a solid block."

The interrupter serves the purpose of closing and opening the primary current, and by so doing leads to the production of a momentary current in the secondary. This is used for the stimulation of the X-ray bulb. The induction coil possesses the property common to all high-tension transformers, of changing a low-tension current into a high-tension alternating current of high potential. The production of this high-tension current is the object of the construction of the coil and the accessory apparatus connected to it; the parts described are the essentials, but there are always accessories in a complete installation which have an important bearing on the efficient action of the installation, though they need not be described here.

Having considered the essential parts of an induction coil, we are now in a position to study the production of high-tension current and its action upon the X-ray bulb; in other words, the production of X-rays.

The important things for the beginner to grasp are: (*a*) That the induction coil or transformer is essential for the production of the high-tension current necessary for the energising of the X-ray tube and the production of the X-rays from it; (*b*) a supply of low-tension current is required for the energising of the coil or transformer, and that, provided this current is ample for the purpose, it does not matter whether it is produced from primary batteries or from the electric mains.

In the latter case the power station of the supply takes the place of the simple batteries or the petrol set, and the result is a supply of continuous or alternating current for the working of the coil, according to the form of current supplied by the power station. The complicated apparatus attached to the incoming leads consists chiefly of control switches, fuses, resistances, meters, and other regulating apparatus to enable the supply of current to be readily modified to meet the requirements of the apparatus in use.

Action of an Induction Coil.—Fig. 28 represents the simplest pattern of contact breaker; it is only used now for simplicity of description, for a mercury interrupter takes its place in all modern coil installations.

" H " is a piece of soft iron carried on a stiff brass spring which is pulled towards the magnet " T " whenever the latter is magnetised. " T " is the core of the coil.

" B " indicates a pair of platinum-tipped contacts, one piece attached to the brass spring and iron pole piece " H," the back one fixed to an adjoining screw " d " working in a collar " h," so that the distance between the platinum tips can readily be adjusted.

The current passes from the positive pole of the battery or mains "T_1" into the adjusting screw "d," thence through the platinum contacts "B" along the primary winding "PP," and then back to the negative pole "T_2."

The electrical circuit being thus completed, the core "T" becomes magnetised and attracts the iron hammer "H," the platinum contacts are therefore pulled apart and the circuit is broken. The core now becomes demagnetised, and the platinum contacts are again pulled together by means of the brass spring. Contact again being made, the core "T" is once more magnetised and the process of magnetisation and demagnetisation goes on as long as the interrupter continues to act.

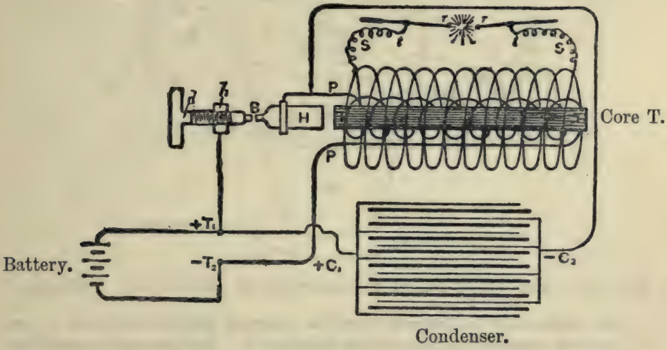


FIG. 28.—Plan of winding of coil (primary, secondary) and connection to condenser and break. (Newton and Wright.)

When a mercury interrupter is employed the operation is precisely similar as long as the interrupter acts efficiently.

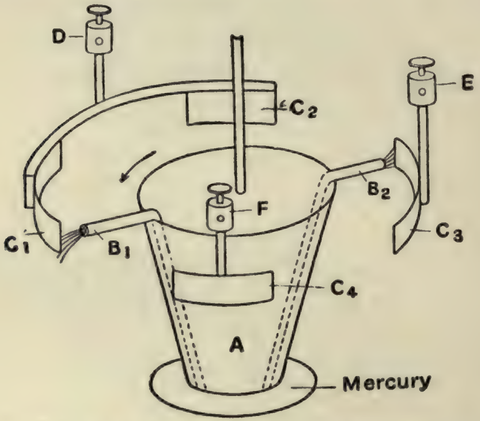


Fig. 29.—Method of action of a mercury jet interrupter. (Watson.)

On reference to the diagram it will be observed that two contacts, C_1 and C_2, are both connected to the common terminal D. This terminal is connected with one of the supply wires. One of the remaining terminals, say E, is then connected to the induction coil, and the other terminal of the induction coil connected back to the supply.

When the jets B_1 and B_2 are in the position shown the current will enter D and will pass from contact C_1 by way of the jet down the tubes of the pump A, out again to the jet B_2, on to contact C_3, and thence through the induction coil and back to the supply.

The diagram shows the pump in such a position that the current is just about to be broken as the jet leaves the contacts C_1 and C_3.

If the terminals E and F are externally connected, it will be noted that the frequency of interruption will be doubled as current will also pass between C_2 and C_4 when the jets are in that position.

The condenser "C" acts in the following manner:

When the contact at "B" is broken the current passes into one side of the condenser at

"C," and by providing the alternative path the necessary sparking at "B" is greatly reduced, and, what is of much greater consequence, the suddenness of the break, and therefore the speed at which the core becomes demagnetised, is greatly increased.

With each interruption in the primary current changes are induced in the secondary winding of the coil; at each "make" of the interrupter an induced current appears in the secondary, and at every "break" another induced current appears in the opposite direction.

The current which passes between the secondary terminals of the coil and through the tube should be unidirectional; it is chiefly derived from induced current appearing at the "break" of the interrupter.

The great disadvantage of the coil as a source of high-tension current lies in the difficulty of maintaining a supply of unidirectional current. Many ingenious methods are employed for the suppression of the inverse current.

Electrolytic Interrupter.—This type was introduced by Professor Wehnelt. The principle of construction is simple. A platinum wire and a large lead electrode are immersed in diluted sulphuric acid in the proportion of 1 oz. acid to 5 oz. of water. The specific gravity of the mixture should be 1·2. It may be tested from time to time by using a hydrometer. Variations in the specific gravity may explain the defective working of the interrupter.

This interrupter is without doubt a good one, far exceeding the best mercury interrupters, not only in regard to output and capacity for regulation, but also in simplicity of construction and use, as well as in safety of working. Wehnelt interrupters can be used wherever continuous current is supplied direct—*i.e.* from supply mains, accumulators (at least about 65 volts), or a motor generator, or where single-phase or three-phase current is converted into continuous

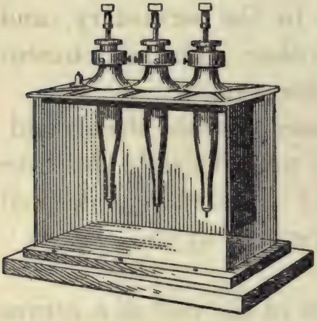


FIG. 30.—Three-point electrolytic interrupter. (Siemens.)

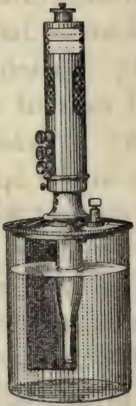


FIG. 31.—Single-point electrolytic interrupter. (Watson.)

The upper part of the interrupter has attached to it a solenoid which is connected electrically to the switch-table, allowing of the control of the depth of point in the fluid.

current by means of rotary converters or electrolytic valves. As all metals, with the exception of platinum, when used for the active electrode, even if the polarity is correct, are rapidly disintegrated, platinum is always used with these interrupters as the active electrode, because it disintegrates very slowly and therefore gives the best results. These interrupters are manufactured with 1, 2, 3, 4, or 6 separate electrodes, *i.e.* they are used as single, double, triple, quadruple, or sextuple interrupters. When employing a multiple interrupter it is not necessary to regulate at the interrupter itself. The control can be placed on the switchboard, the interrupter being placed outside the X-ray room, so that its noise causes no disturbance, and in this way the objectionable fumes from the decomposition of the fluid in the interrupter are got rid of. The interruptions are very rapid, as high as 1500 or 2000 per second when a small anode point is used. With large currents the frequency is not so great.

HIGH-TENSION TRANSFORMERS

The Step-up, High-tension Transformer.—In this apparatus the interrupter is unnecessary. The condenser is also dispensed with, and on account of the absence of inverse current the need for the use of valve or rectifying tubes is obviated.

The high-tension transformer is a most efficient piece of apparatus, and should in time displace the induction coil.

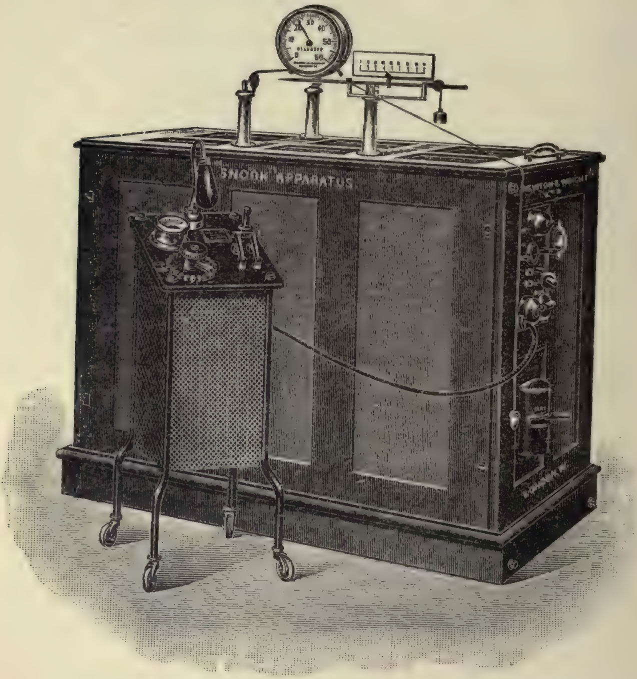


FIG. 32.—Snook Apparatus. (Newton and Wright.)

A brief description of one of the well-known types will enable the reader to understand its mechanism and action.

The **Snook apparatus** was the first interrupterless machine made in a practical form for X-ray work, and was made in England in 1907, the credit of the design being entirely due to Mr. H. Clyde Snook of Philadelphia, who made the first model which still bears his name.

The machine consists essentially of three parts—the motor converter, the high-tension transformer, and the high-tension rectifier or commutator. In the case of the machine designed to run on continuous current, the part first named consists of a motor, usually about 4 k.w. in size, which runs from the main at about 1500 revolutions per minute. This machine has a pair of so-called slip rings, from which can be obtained an alternating current.

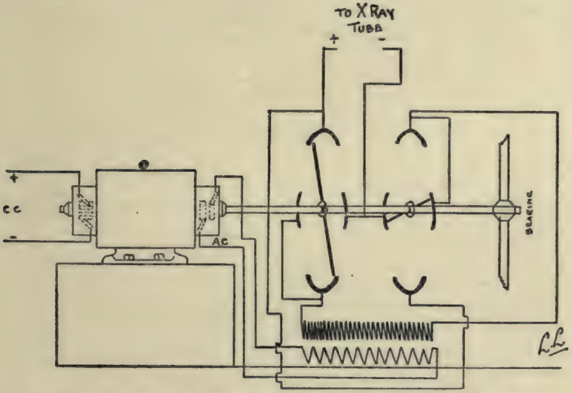


FIG. 33.—Diagram of Snook Apparatus. (Newton and Wright.)

This alternating current is connected to the primary circuit of the transformer through a controlling rheostat, and is raised in electrical pressure or voltage to the necessary tension for X-ray work.

This high-tension current is, however, alternating in character, whereas for the production of X-rays it is necessary to have a discharge in one direction only, and the latter is obtained by means of the high-tension rectifier.

Rectifying Device.—This consists of a round vulcanite disc to the periphery of which are fastened metal strips opposite each other, and occupying a little more than a quarter of the circumference. They are so arranged that when rotation of the disc takes place they make contact with conductors placed in ebonite tubes. The disc is rotated by the motor converter.

In revolving the conductors, connect the current from the secondary or high-tension side of the transformer to the spark-gap, to which the X-ray tube is finally connected, and also reverse the direction of the part of the alternating current, which would otherwise pass through the tube in the wrong direction.

The great feature of the machine is that this rectifier is carried on the shaft of the motor which is generating the initial alternating current by virtue of its rotation, and therefore the machine cannot get what is called "out of phase."

The general arrangement of the different parts is shown in the diagram below, and the whole mechanism is entirely enclosed in a cabinet of polished woodwork to deaden the otherwise disagreeable noise of the apparatus when in action.

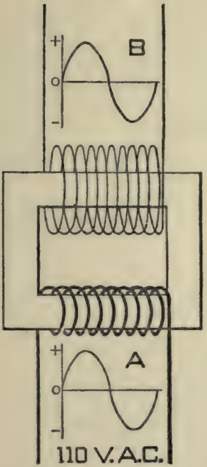


Fig. 34.

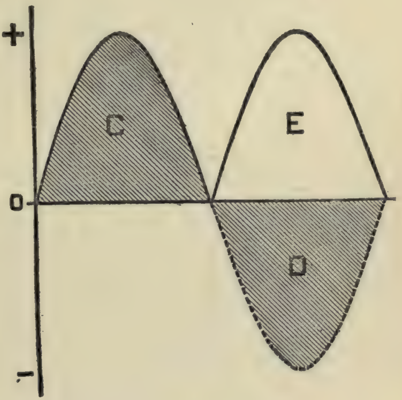


Fig. 35.

Fig. 34 shows the elementary principle of the closed circuit-transformer. A is the primary coil, B the secondary, or high-tension side. This secondary is designed to give a sufficient voltage to jump across an 8- or 10-inch gap.

The character of an alternating current has a wave form, as shown in Fig. 35, the shaded areas C-D giving a complete cycle. The wave form of the secondary discharge is also the same. However, it cannot be used for radiographic work, as the wave must be of a pulsating nature, totally on the one side of the zero potential line, to make the current unidirectional. To obtain this characteristic a mechanical rectifying device is needed. This is seen in Fig. 35, C, the wave. On its downward slope it intersects with the zero line. At this point it is necessary to reverse the electrical conductive paths so as to take the next wave or alternation and transpose it to position E, making it unidirectional.

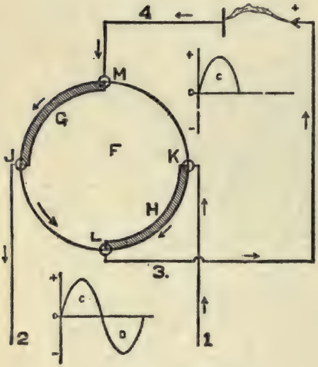


Fig. 36.

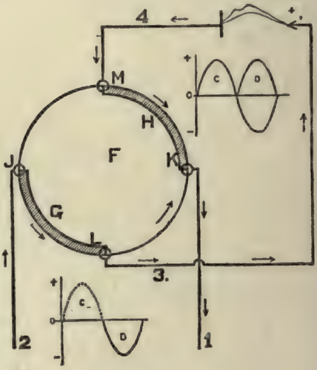


Fig. 37.

Figs. 36 and 37 give a diagrammatic idea of the rectifying device. F is the mica disc, G and H are two copper commutator strips fastened to the periphery of the disc opposite each other and occupying a little more space than a quadrant. J and K are high-tension alternating current brushes. L and M are the brushes which receive the rectified current. For one complete cycle, or two alternations, the disc makes half a revolution. Fig. 36, wave form C, shows the first alternation during this period; the disc has made a quarter of a revolution and attained the position shown. Fig. 36, Nos. 1 and 2, are the alternating high-tension current leads to J and K.

The wave C shown between Nos. 1 and 2 is the character of alternation. Assume No. 1 is of positive (+) polarity in that instant; the direction of the flow is then shown by the arrows. The wave form after rectification is shown between conductors Nos. 3 and 4. In Fig. 37, D, is shown the next alternation and reversal. The disc has now changed its position from Fig. 36 to Fig. 37. Conduit No. 2 is now positive, and the current flows as shown by the arrows. It can be seen that the polarity of the discharge has still been maintained, showing that all the positive (+) impulses are conducted along No. 3 and the negative (−) impulses along No. 4, thus giving absolute unidirectional current.

If an alternating current is available, the motor converter is replaced by a small synchronous motor for rotating the rectifier, the main current being used in the transformer direct.

In this case the synchronous motor must be very carefully designed and constructed, otherwise it will cause trouble if there is any possibility of its running other than absolutely in step or synchronism with the current.

This apparatus is much preferred to an induction coil by many workers, owing to the possibility which it affords of using very powerful currents, enabling practically instantaneous radiograms of any part of the body to be taken, and also on account of the ease with which the current can be regulated.

The machine, moreover, produces a perfectly unidirectional current, entirely free from any inverse discharge in the wrong direction, this being a great advantage from the point of view of the life and general working condition of the X-ray tube.

The Production of X-rays in an X-ray Bulb

The high-tension current necessary for the stimulation of the X-ray tube is led from the positive pole of the induction coil or transformer to the positive pole of the X-ray tube, *i.e.* the anode. If it has a sufficiently high voltage to enable it to pass across the interval in the bulb between the anode and the cathode it passes steadily in the direction from the positive to the negative pole of the tube. The voltage requires to be very high—from 50,000 to 100,000 volts or more according to the degree of exhaustion of the

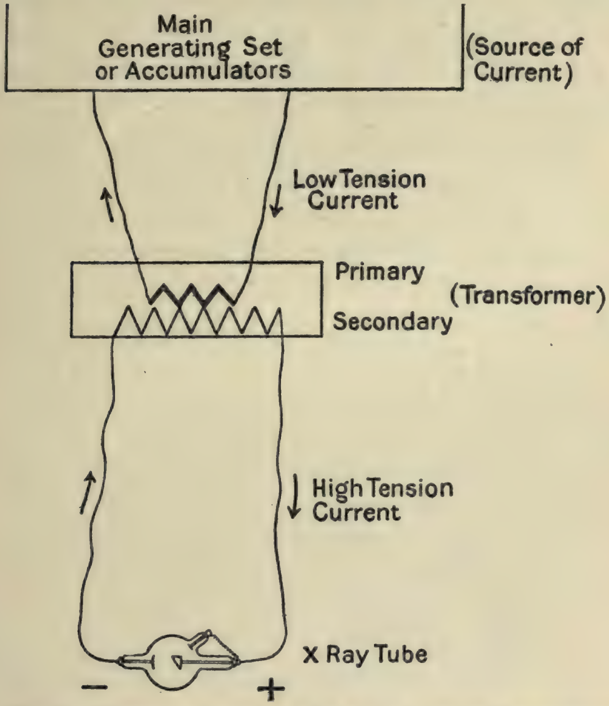


Fig. 38.—Diagram illustrating the path of current from source through X-ray tube.

bulb—*i.e.* hardness. The incoming high-tension current in a properly constructed tube meets the cathode terminal, which is generally a cup-shaped piece of aluminium. From the point of impact "cathode waves" are given off; these possess negative physical properties which need not be elaborated here.

The cathode wave is focussed upon the anti-cathode of the tube, and at the point of focus rays are given off (electrically charged) which pass through the glass wall of the tube; the term X-rays was applied to these rays by Röntgen; the name has remained ever since. These rays emerging from the X-ray bulb have peculiar physical properties, and in radiography and radio-therapeutics advantage is taken of these properties, enabling us to produce radiographs, examine patients on the fluorescent screen, and to exercise an influence on the tissues which is taken advantage of in therapeutics.

THE ACCESSORY APPARATUS

Apart from the essential apparatus there are a number of accessory pieces of apparatus which all help to facilitate the carrying out of the examination or treatment. These need not be described in detail, but a reference to them is necessary if the reader is to obtain a clear conception of the descriptions of technique given in their appropriate places.

The following pieces of apparatus require to be briefly described and illustrated:

(1) The tube-stand.
(2) The X-ray couch.
(3) The X-ray screening stand.

The following protective devices are necessary:

(*a*) *For the Patient.*—The modern tube-stand is sufficiently protected to ensure the safety of the patient except when prolonged treatment is given, and then all parts of the body except those under treatment should be protected from stray radiations.

(*b*) *For the Operator.*—During screen examinations the operator should always wear lead-rubber gloves; protection of the body by lead-rubber aprons is also good, but these are very heavy, and it is more usual now to take precautions in the tube-box against radiations escaping beyond the field under observation. As an extra precaution in the case of prolonged screening, a protective screen will be found useful.

The Tube-stand.—The pillar-stand consists of a solid pedestal with castors, which carries a vertical column of steel tube. An adjustable sleeve, to which one end of the wire is secured, is mounted on this column. The wire runs over a pulley, and carries a movable lead weight inside the steel tube; this serves to balance the tube-box and the whole movable system. The sleeve can be locked in any position by a lever. The pulley is secured to a ball-bearing mechanism, and revolves freely round the top of the column. The sleeve, together with the tube-box, can be turned radially to the arm. Thus the tube-box can be moved as follows: (*a*) Up and down; (*b*) round the column; (*c*) round the arm; (*d*) through an angle of 90° round any axis vertical to the arm; consequently the pillar-stand permits of the adjustment of the position of the tube within the widest limits.

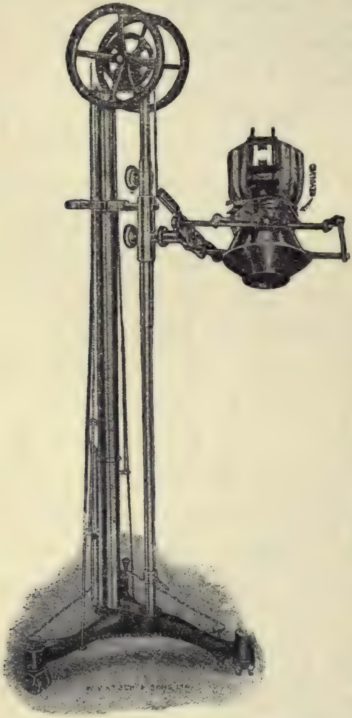


FIG. 39.—A form of tube-stand which combines many useful mechanical movements. (Watson.)

The tube-box is lined inside with lead-rubber material for purposes of protection. Its back forms a door through which the tube is introduced. The front is provided with a rectangular or circular opening of about 170+220 mm., in front of which is fitted a rectangular or iris diaphragm controlled by a mechanism placed at a distance from the stand and conveniently for the operator to handle. In order to allow manipulation of the tube-box during adjustment, it is provided with a handle.

X-ray Examination Couch.—The essential points of such a couch are:

(1) Conveniences for the adjustment of patient, tube, and plate.

(2) Safety for patient and operator against the dangers of over-exposure to X-rays.

So far as the patient is concerned these points can be obtained by: (*a*) Limitation of the time of exposure; (*b*) distance of the tube from the skin surface; (*c*) the interposition of a thin aluminium filter (2 mm.) between the patient's skin and the active tube.

The operator should take all known measures of protection: (*a*) careful shutting in of the tube by tested X-ray-proof material; (*b*) the use of gloves and aprons, or the interposition of a lead-lined X-ray-proof screen between the body and the tube; (*c*) the protection of the fluorescent screen by lead-glass; (*d*) the minimum time for each exposure.

It is necessary to remember that, in spite of all precautions, if screening is employed daily over a long period of time no protective measures can be considered absolutely safe.

A **simple couch** will suffice for a small installation. In large institutions, where a considerable amount of work has to be got through, a couch with mechanical contrivances is necessary. The couch should be sufficiently protected, and should have conveniences for working

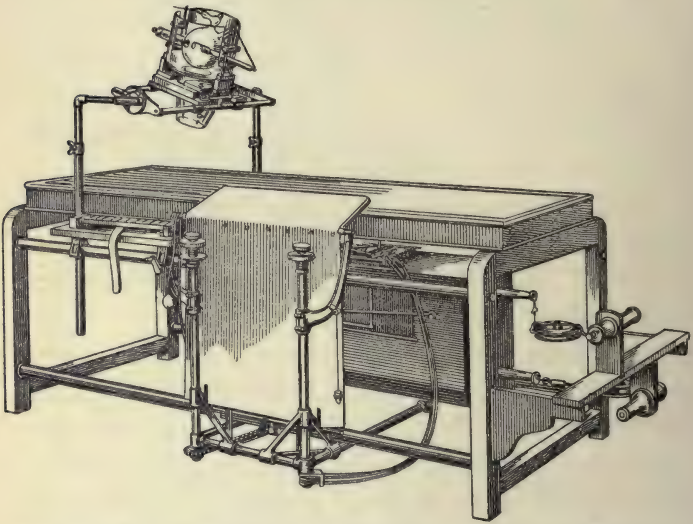


FIG. 40.—A convenient form of X-ray couch. (Newton and Wright.)

Fitted with a protected tube-box, the top of the table is so constructed that the patient may be moved in several directions to facilitate centring of parts of the body over or beneath the X-ray tube.

with the tube below or above the table. When possible, overhead work should be undertaken.

The screening stand illustrated on p. 176 is constructed for screen examinations and exposures from the screening position only. It is an excellent stand for those specialising in screen examinations. It is constructed in two units.

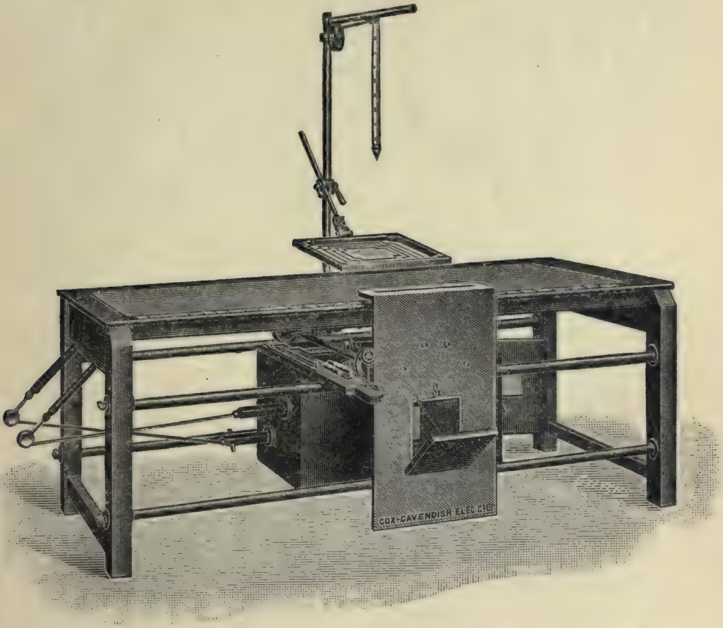


FIG. 41.—The X-ray couch or examination-table. (Cox-Cavendish Co.)

This couch can also be used for treatment, but patients who require to remain on a couch for an hour or more must have comfort; for treatment, therefore, a lounge-couch well padded will be preferable.

One unit might be called the screen unit and the other the tube-box unit. The former consists of a frame carrying the fluorescent screen and plate-holder, which fits into a parchment frame marked with divisions, so that a note can be made of the exact position, and an examination repeated in a similar position at a later date. This frame and screen is counterbalanced, and can be easily raised or lowered in a large upright framework. On the back of this framework are fitted, at convenient intervals, bands for passing round the patient to keep him in a fixed position. There is also a lamp which throws a light on the scales of the second part of the apparatus. The latter, or second part, consists of a large protective lined tube-box, mounted on a frame which is carried on a second upright framework, and from this project forward, one on either side, two long arms with convenient wheel handles, one on the left-hand side for rais-

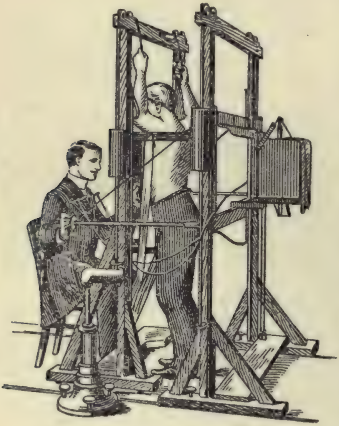
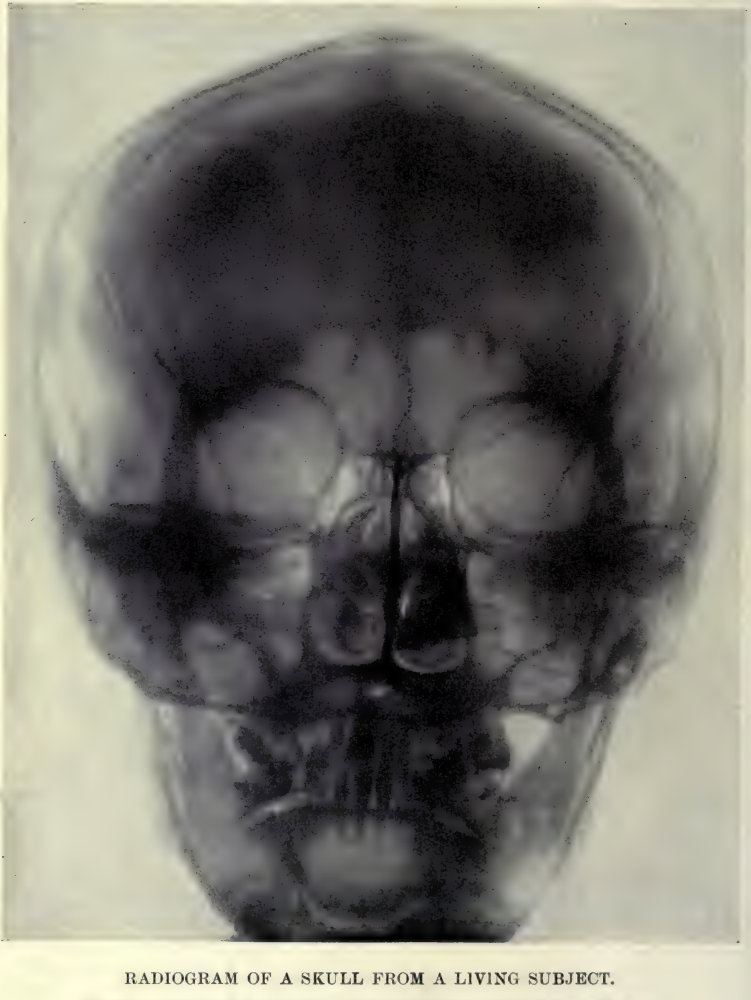


FIG. 42.—Wenckebach Screening Stand. (Siemens.)

PLATE XXX.



RADIOGRAM OF A SKULL FROM A LIVING SUBJECT.

Showing anatomical landmarks. The accessory air sinuses are well seen.

ing and lowering the tube-box, and one on the right for moving it across from side to side; also close beside the latter are the two flexible cables and handles for controlling the aperture of the diaphragm. This second part is mounted on rails laid in the floor, and the object of the long arms is to enable the operator, while making his screen examination, to push the tube farther away or draw it nearer the patient with the utmost comfort and ease. A stool can also be provided to support the patient if necessary.

THE PATH FOLLOWED BY THE ELECTRICAL CURRENT IN THE CIRCUIT OF A TUBE FOR THE PRODUCTION OF X-RAYS

The current is taken from the positive pole of the secondary current circuit (*i.e.* the high-tension current). It passes from the sparking pillar (see Fig. 43) along the high-tension lead to the positive pole of the X-ray bulb (the anode); from this terminal it passes along the anode terminal to reach the gap between the anode and the cathode. It then travels from the negative pole of the tube to the negative lead and back to the negative high-tension terminal of the coil.

Since the interrupter is making a given number of interruptions per minute it follows that for each interrupter a momentary current is induced in the secondary. This current is twofold —*i.e.* an induced current at the "make" and at the "break." The make current passes in one

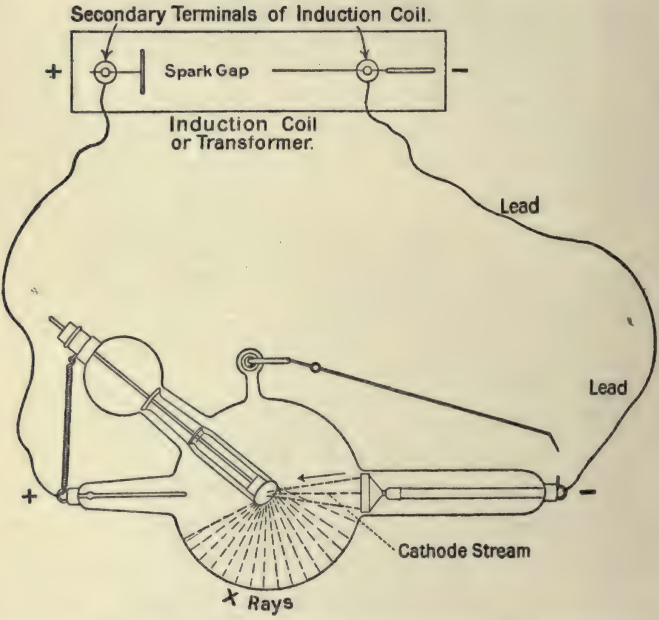

Secondary Terminals of Induction Coil.
+
Spark Gap
−
Induction Coil or Transformer.
Lead
Lead
+
−
Cathode Stream
X Rays

FIG. 43.—Diagram illustrating the production of X-rays.

direction, the break in the opposite. The current for the energising of the X-ray bulb must be "unidirectional"; consequently current at "make" must be suppressed if ill-effects on the tube are to be avoided; besides, "inverse" current has a deleterious effect upon the negative when it is produced.

In spite of all precautions a certain amount of inverse current may pass, and this exercises an injurious effect upon the quality of the plate or the sharpness of the fluoroscopic pictures.

In order to minimise these effects, diaphragms are used in conjunction with metallic extension tubes; lead readily absorbs the secondary and scattered radiations, and is therefore used for the diaphragm and for lining the extension tube. The lead diaphragm is fitted into the floor of the X-ray tube-holder.

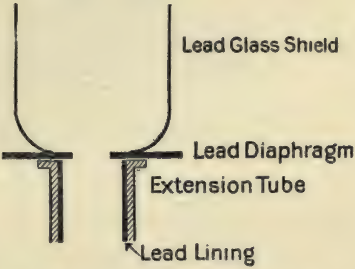


FIG. 44.—Sectional diagram of extension tube.

The principle on which these act is explained by Figures 45 and 46.

There are several methods employed by means of which the inverse current is either suppressed or a unidirectional current produced.

With coil outfits the construction of the coil exercises a considerable influence over the amount produced, or a condenser is introduced to aid in the suppression of the inverse. With most coil outfits it is necessary to use valve tubes. These are vacuum tubes introduced into the circuit, and they are capable of suppressing a considerable amount of inverse current. The principle on which they are constructed is dependent on the knowledge that a high-tension current passes more freely between a point and a plate if the point is the + pole, but it does not so readily do so if the point is the − pole. It is therefore possible to create an impediment or higher resistance to the current in one direction only, the passage in the other direction being free.

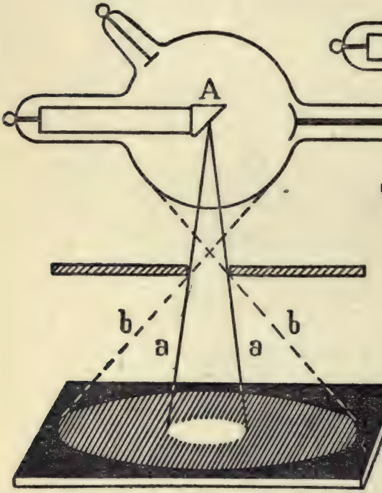


Fig. 45.—Diagram showing the use of a diaphragm between tube and plate. (Schall.)

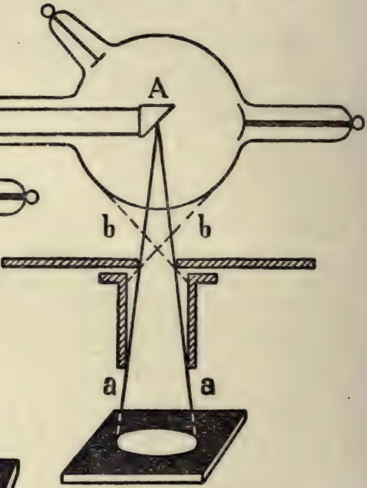
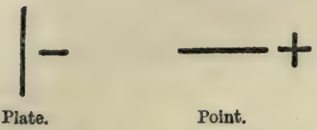
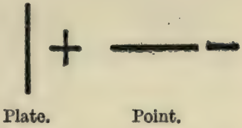


Fig. 46.—Diagram showing the use of a cylinder diaphragm. (Schall.)





Valve tubes are arranged to act in this manner. With the object of suppressing the current at "make" a spark-gap introduced in the circuit serves the same purpose.

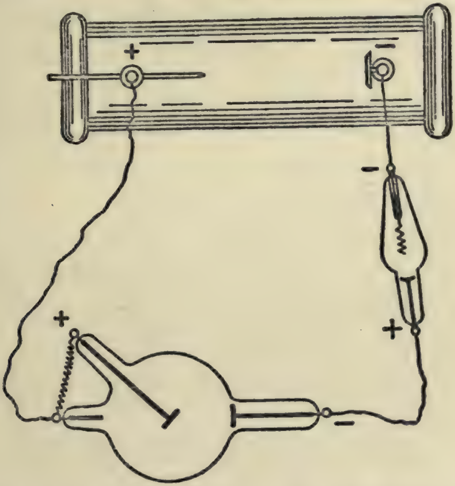


FIG. 47.—Connection of X-ray tube to the coil, showing coil and connections to tube. A valve tube is here inserted on the negative pole.

PHYSICAL PROPERTIES OF X-RAYS

The X-rays are not visible to the naked eye. The three chief physical indications of their presence are: (1) Their photographic action: advantage is taken of this property in radiography of the various parts of the body. (2) Their power of causing many bodies to fluoresce: this property is used when an examination of the body is made by means of the fluorescent screen (a cardboard sheet coated with platinocyanide of barium; this is mounted in a frame and covered with a sheet of lead-glass): fluoroscopy is one of the routine methods of examination now in use. (3) Their ionising power—*i.e.* their capacity of producing ions in substances. This property is the underlying one in practical therapeutics, and on its intelligent appreciation is based the theory of practical radiation therapeutics.

Photographic Action.—A solid body, a coin or a bone, or even soft tissue—obstructs the X-rays when they are allowed to act upon it. The degrees of opacity of these bodies gives an indication of the amount of absorption each body possesses for X-rays.

The depth of the shadow depends upon the density and thickness of the material used. As a result of this a radiograph of a part of the body, such as a hand, shows a picture composed of shadows of the component parts on the plate; the soft tissues are outlined, while the bones give complete shadows showing the intimate structure of the bones (arteries may in some instances also be shown if their walls are sclerosed or atheromatous). The amount of absorption of the rays by the denser structures gives rise to the variation in the depth of shadows. In practical radiography the outline of hollow organs may be shown by placing in their interior opaque substances such as bismuth, barium, and collargol, metal sounds, bougies opaque to the rays, etc. The opaque meal has become a routine method of investigation in diseases of the alimentary canal; collargol injection of the bladder, ureter, and kidneys in diseases of these organs.

Fluorescence.—Many substances show fluorescence when exposed to the action of X-rays. The rays proceeding from the X-ray bulb (*i.e.* a gas-tube) cause the glass to fluoresce with a greenish-yellow light, the exact tint depending upon the character of the rays. The gas in the bulb plays some part in the production of the fluorescence; a tube of low vacuum shows less colour than one of high vacuum, and the Coolidge tube, which is exhausted to a high degree, shows practically no fluorescence.

Ionisation.—Substances known as dielectrics, normally bad conductors of electricity, have electrical conductivity conferred upon them when subjected to X-radiation. X-rays in their passage through air confer upon it a degree of conductivity which is easily measured by means of an ordinary gold-leaf electroscope. The air has become ionised during the passage of the X-rays through it. The explanation given of ionisation of gases is that the process consists of the liberation of one or more electrons from a molecule. The electron, carrying away a negative electrical charge, leaves the remainder of the molecule positively charged. This condition is momentary only, for the liberated electron quickly becomes the nucleus of a cluster of uncharged molecules which form around it. This also takes place in the positively charged particle; the result being that positively and negatively charged clusters of molecules are formed in the gas in equal numbers, and these are what are referred to as gaseous ions.

The ionising action of X-rays is exceedingly powerful, and is, moreover, one which lends itself to exact measurement. On this is based one method of measuring the action of X-rays and other radiations in practical work.

THE PRODUCTION OF THE RADIOGRAPH

The brief explanation of X-rays and their physical properties will have enabled the reader to grasp sufficient of the details to understand the processes which are employed in everyday radiography.

The examination of a subject consists of fluoroscopy, or radioscopy, and radiography. The former is the examination by the use of the fluorescent screen, and elaborate technique has been elaborated for the examination of special regions. It is a most useful routine in examination and gives very valuable evidence of the presence of disease.

Radiography, or the taking of a radiograph, is the final step, so far as the technique is concerned. It consists in exposing a photographic plate to the X-rays, the subject being placed between the source of the rays and the plate. There are many points of procedure which go to make up the more or less elaborate technique of present-day radiography. These points in technique are briefly dealt with under the appropriate headings in other parts of the work. So far as the actual preparation of the radiograph is concerned there are a number of points which should be briefly referred to in order to convey to the reader's mind an idea of the processes employed.

The production of X-rays and a consideration of the accessory apparatus bring us up to the point of the actual technique. An appreciation of the physical properties of X-rays will enable the reader to understand how the impression is made upon the photographic plate.

Technique. — The first thing to consider is the patient and the part of the body that is to be radiographed. Any part may have to be examined; consequently there are a number of positions of the body which may be more or less standardised. It is not intended to deal with these in order, since they will be found fully described in text-books devoted to a fuller technique. The exposure of the photographic plate calls for a more detailed description.

A simple example will suffice. A hand is the object chosen. A photographic or X-ray plate in its light-tight envelopes is placed in a cassette or plate-holder, or laid upon the surface of the table. The hand must be kept absolutely still during the exposure, so it is necessary to employ some method of fixation. This is best done by using a number of pads of cotton-wool or other substance which does not absorb the radiations to any extent. The extension tube in the tube-box is now brought down upon the pads and pressure applied—thus:

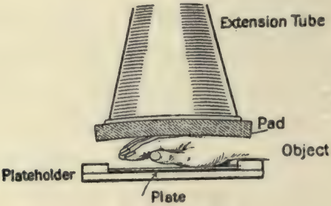


FIG. 48.—Illustrating the use of an extension tube.

The X-ray tube must have been accurately centred in the tube-box. Several simple methods of centring are in use, the object being to employ, as nearly as possible, what is known as the "central ray"—*i.e.* that bundle of rays which proceeds from the focus point of the anti-cathode. It is of the utmost importance that the tube should be centred accurately in all work which is to be used for the purpose of ascertaining the position of a foreign body or a piece of necrosed bone. For localisation of foreign bodies in the orbit and eyeball this is the most important point in the whole technique. The tube may be employed in a tube-stand over the table, or it may be placed beneath the table, and the patient examined from below. In whichever position the tube is used it must be centred accurately.

The next point to consider is the duration of the exposure. That will depend upon the following factors:

(*a*) The intensity of the radiation—*i.e.* amount of current passing through the tube and the penetrative value of the radiation.

(*b*) The thickness of the subject, and the density of the tissues of the patient. Patients vary in the latter respect.

(*c*) The distance between the surface of the plate and the source of the X-rays—*i.e.* the anti-cathode of the X-ray bulb.

The duration is increased in proportion to the square of the distance.

(*d*) The sensitiveness of the photographic plate.

For our present purpose it is hardly necessary to further elaborate the above points.

The exposure is expressed in seconds or fractions of a second.

The length of the exposure is, as has been already stated, directly proportionate to the intensity of the radiation; consequently, if the apparatus is powerful enough, it may be possible to obtain satisfactory radiograms in much shorter times than those quoted above. Thus by using intensifying screens it is possible to get a picture of an adult of the thorax in about $\frac{1}{100}$th of a second, with proportionally shorter times for parts which do not offer as much resistance to the passage of the radiations.

The use of an intensifier screen shortens the exposure about 10 times—*i.e.* $\frac{1}{10}$th of the exposure necessary when it is not used. The screen is therefore a useful adjunct in the radiographic room.

Up to the present stage the exposure of the X-ray plate differs from that of an ordinary plate used for daylight photography in that no lens is employed in the former. A "shadowgraph" is the proper descriptive term to employ. The rays are not focussed, though the term focussing is erroneously employed in relation to radiographic technique. Immediately the exposure has been made the plate is treated in exactly the same way as in ordinary photography. A knowledge of photography is therefore very useful for the radiographer, particularly in dealing with development, fixing, and printing from X-ray negatives.

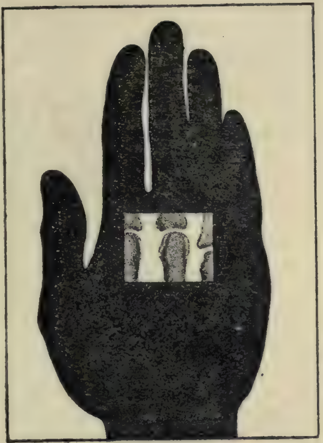


FIG. 49.—Diagram showing the advantage of using an intensifying screen. (Watson.)

The developed plate is fixed in hyposulphide of soda in the ordinary way. After fixation it is well washed in running water and then allowed to dry.

We now have a negative upon which is a picture of the part radiographed. This may be viewed in a box specially constructed for the purpose, with electric lamps inside to light the picture. The developed plate is all that we require for the purpose of diagnosis, though in a number of instances it may be necessary to obtain a positive or print from the negative.

The examination of the negative is most important in diagnosis. Great care must be exercised in the majority of cases. It may be necessary to examine several plates from the same subject and to compare them with a normal when a difficult point in diagnosis has to be cleared up.

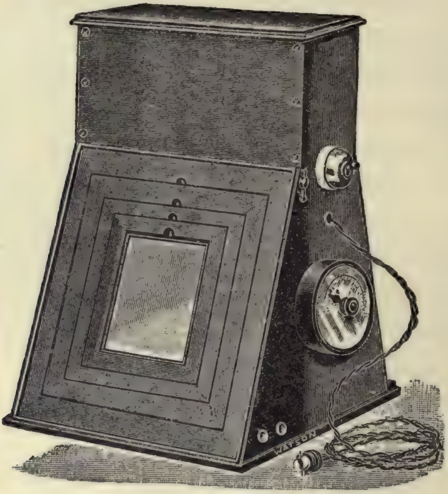


FIG. 50.—A useful viewing box. (Watson.)

A viewing-box large enough to hold six or more large plates is a useful addition to the dark-room; then it is possible to examine in series a number of plates.

The positive differs from the negative in that it is a reversal of the latter, parts which appear black in the negative are white in the positive, and *vice versa*.

In order to obtain a good print this point has to be borne in mind. In the exposure of the subject the X-rays are absorbed in proportion to the density of the structure through which these rays pass; consequently, when the absorption is great, fewer rays will reach the plate, and a lesser quantity of the silver salt be acted upon. On the developed plate the appearance will be lighter—*i.e.* more nearly approximating to the glass.

This part when acted upon by light in printing will be more easily affected, and therefore will appear blacker when the print is developed. The process is an exact reversal of the negative formation. In order to obtain a good print it is necessary to shade parts of the negative during the exposure. This is a fine technical point in photography which does not receive the attention from X-ray workers which it deserves.

The print is developed, fixed, washed, and dried. To obtain a good flat surface the print should be squeezed down on glass or a ferrotype plate and allowed to dry.

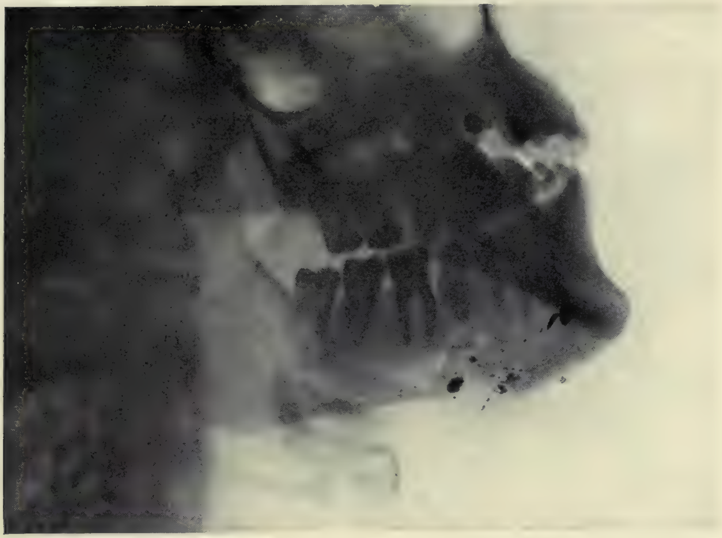
STEREOSCOPIC RADIOGRAPHY

Two pictures formed in the right and left eye when looking at the same object are slightly different; for the simple reason that they are not seen from the same point of view.

In order to obtain a sense of relief when viewing two pictures of the same object we must present to each eye a different picture, similar to the one each would see when looking at the object itself. The two pictures (known as stereoscopic pictures) should be taken from two points of view, between which the distance is equal to the separation of the eyeballs.

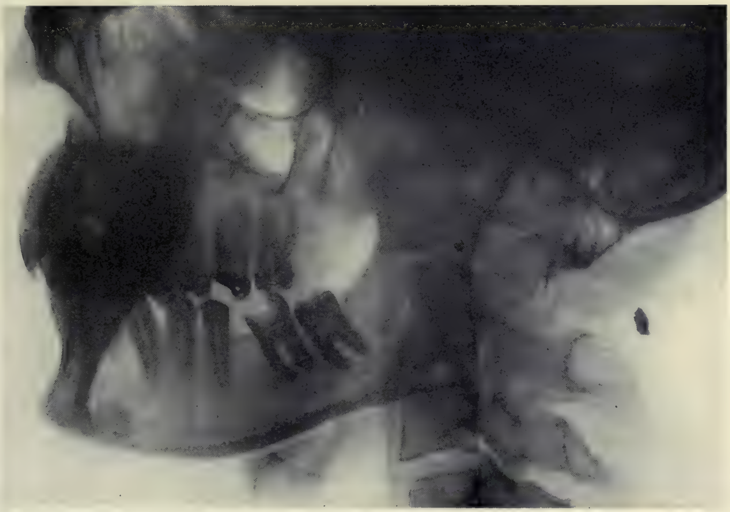
For certain objects, and particularly in radiography, the distance may have to be augmented in order to enhance the stereoscopic relief.

In radiography the interval chosen is generally 6 centimetres, but in some instances, especially for purposes of localisation, the distance may be increased to 10 centimetres between the two positions of the X-ray bulb. The tube is centred over the object; then for the first exposure it is moved to the right 3 or 5 centimetres, and the exposure is made. This is marked "right shift of the tube." A second plate is placed in exactly the same position as the first one. The tube is now moved 6 or 10 centimetres to the left and an exposure made. This is known as the "left shift of the tube." The plates are developed, and we now have two pictures taken from two points of view, *i.e.* two



GUNSHOT INJURY OF LOWER JAW.

Fracture with small foreign bodies *in situ.*



SMALL FOREIGN BODIES IN THE CERVICAL REGION.

Note detail of lower jaw and roots of teeth, caries in the second molar.

positions of the tube, and corresponding to the position of the two eyes.

The two negatives must be viewed under conditions which will favour stereoscopic projection of the images.

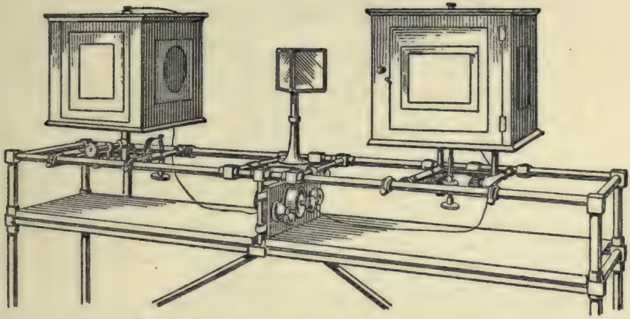


FIG. 51.—A Wheatstone stereoscope.

The pictures are placed in the panels and are reflected into the mirrors set at an angle in the centre.

There are several methods which may be employed :

(1) A Wheatstone stereoscope may be used.

(2) The negatives may be placed in a viewing-box side by side, and examined with a prism stereoscope such as that introduced by Dr. Howard Pirie.

(3) Reduced positives or negatives may be prepared and viewed in a Brewster hand-stereoscope.

(4) The observer, by squinting, may be able to superimpose the images and so obtain a stereoscopic relief.

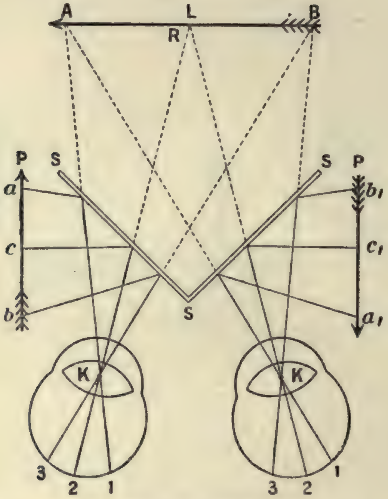


Fig. 52.—Diagram to illustrate the principle of Wheatstone's reflecting stereoscope. (From *Ency. Brit.*)

K, *K*, right and left eyes; *S*, *S*, *S*, mirrors; *P*, *P*, objects in position; *a*, *b*, picture on left side; b_1, a_1, picture on right side; 3 2 1, corresponding points on retina; *ALB*, object as seen in relief in mirrors; *b*, picture seen by left eye in position *B*, and image on retina at 3; *c*, seen at *LR*, and retinal image at 2; *a*, seen at *A*, and retinal image at 1; a_1, seen at *A*, and retinal image at 1; c_1, seen at *RL*, and retinal image at 2; b_1, seen at *B*, and retinal image at 3.

Explanation of Views obtained by changing the Position of the Negatives.—The changing view of the objects on the plate with the change of the position of the plates is somewhat difficult to understand. It, however, becomes clear when we remember that we are looking through the body of the patient and not at it as we do when viewing ordinary photographic prints instead of the radiographic stereoscopic plates, so that if we

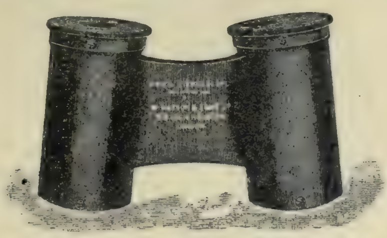


FIG. 53.—A Pirie stereoscope. (Watson & Sons.)

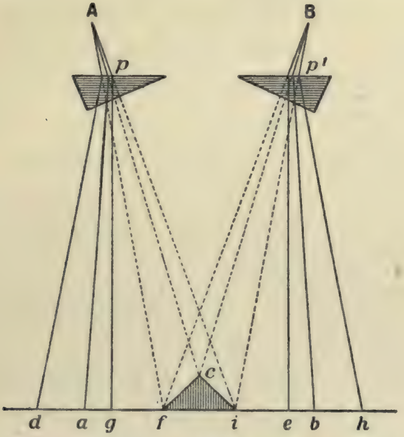


FIG. 54.—Diagram to illustrate the principle of a refracting stereoscope. (From *Ency. Brit.*)

A, left eye; *B*, right eye; *a*, *b*, corresponding pictures for each eye; *p*, *p′*, prisms of glass. The prism *p* refracts the ray *ap*, in the direction of *pA*, as if it proceeded from *c*,; thus *a* and *b* combine to form the point *c*; *d* and *e* combine to form the point *f*; *g* and *h* combine to form the point *i*.

view the body as seen on the radiograph we look through it from whichever point of view we take.

LOCALISATION OF FOREIGN BODIES

Only a brief description of the principles on which the localisation is based is here attempted, with a short description of the methods employed. The value of radiography has been well established during the Great War. Many thousands of cases have been accurately localised in a large number of hospitals at home and abroad. In addition to localisation, radiography has been employed as an aid to the surgeon at the time of operation.

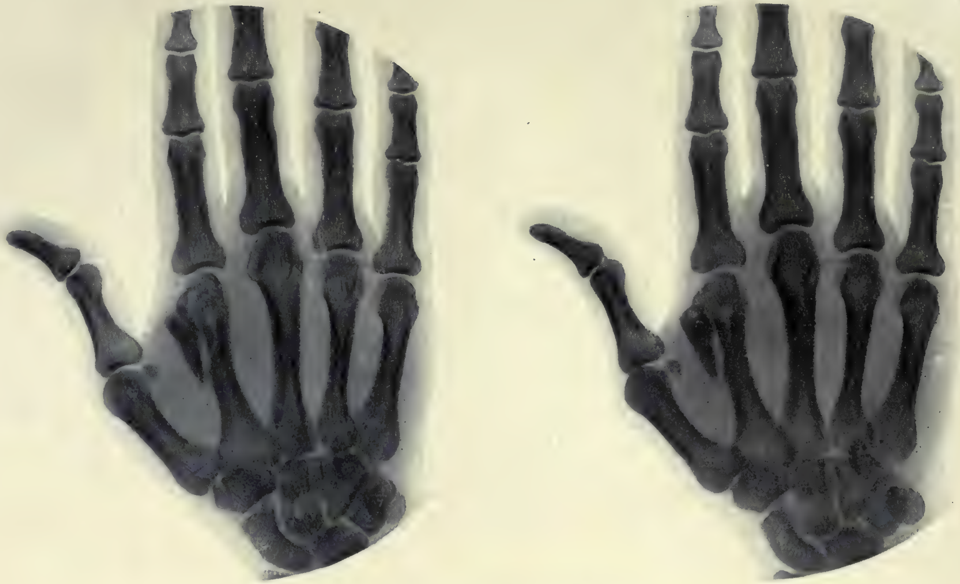
The simplest method of localisation can be carried out with any ordinary apparatus. It is essential that the X-ray tube be accurately centred in the tube-box or holder. The distance between the anti-cathode of the tube and the surface of the plate must also be known and noted. With these two factors in mind it is possible to proceed to a description of the methods of localisation.

There are two methods which are generally adopted:

(1) With the tube above the subject.
(2) With the tube below the subject.

Both are useful, and many workers prefer one or the other. For all-round work, and especially

PLATE XXXII.



STEREOSCOPIC PICTURE OF HAND.

Showing injury to distal end of metacarpal bone of index finger. This plate should be viewed through a hand stereoscope adapted for the purpose.

in times of great pressure, the tube below the table is to be preferred. It is not then necessary to prepare negatives before the localisation can be completed.

In the latter method it is necessary to have a well-constructed couch beneath which, in a protected box, the X-ray tube is accurately centred.

The special couch designed by the late Sir James Mackenzie Davidson is a most convenient one, because it has all the necessary fine adjustments which help to facilitate rapid work.

To the tube-box, and moving with it, is attached a vertical arm carrying at its upper end a horizontal arm, from which is suspended a cord ending in a metal weight (known as a plumb-bob). By suitable mechanical additions it is possible to always have the weight at the end of the string exactly over the point of the table from which the central rays emerge.

The patient is placed upon the couch and the fluorescent screen employed until the foreign body is located. The diaphragm of the tube-box is closed down until a very small aperture is formed. In the centre of the square or circle the foreign body is seen. This constitutes the first stage of the localisation. The plumb-bob is now lowered until the lead touches the surface of the body. This spot is marked. At an unknown depth beneath the mark on the skin the foreign body is situated.

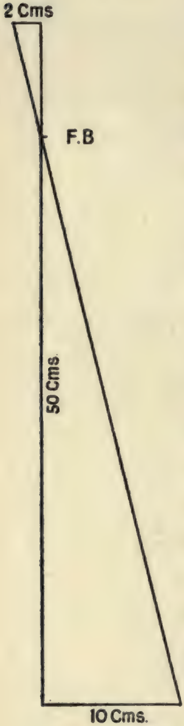


FIG. 55.

The next step is to ascertain the actual depth beneath the skin at which the foreign body is situated. If a screen only is used for localisation the position on the screen of the foreign body is marked. The tube-box is moved along one of the planes of the foreign body and couch a given distance, generally 10 centimetres. The tube-box is fixed. A reading on the screen shows that the shadow of the foreign body has moved. The distance between the two positions of the foreign body is measured and noted. It is now possible to proceed to an estimation of the depth. This is done in the following manner: Diagrammatically it is possible to demonstrate the exact depth by taking a large sheet of paper or a blackboard. Draw a vertical line the same length as the distance between the anti-cathode and the surface of the plate. If the centring has been accurate and the shadow of the foreign body has been carefully arranged in the small fluorescent screen picture in the first position, it represents the line of the central rays in whose path the foreign body lies.

At the lower end of this line draw a line at right angles to it, exactly 10 centimetres long. This represents the distance between the two positions of the anti-cathode. At the upper end of the line draw a second one at right angles, exactly the distance between the two shadows of the foreign body. Now join the two extremities of the horizontal lines by a straight line. The point of intersection of the two lines is the indication of the depth of the foreign body beneath the mark on the skin.

If the vertical line is of the exact length, and it is divided into centimetres and millimetres, then it is easy to read off the depth at once. On this principle many simple instruments have been made to facilitate the rapid estimation of the depth.

When the screen method is relied upon for the localisation it is only necessary to make a mark upon the skin, and beneath this mark, at a determined distance, the foreign body is situated.

The important point to note and to impress upon the surgeon is that the patient must be placed upon the operating-table in precisely the same position he occupied when the localisation procedures were carried out. A failure to recognise the importance of the position of the patient is responsible for many of the failures to find and remove the foreign body when it is surgically accessible.

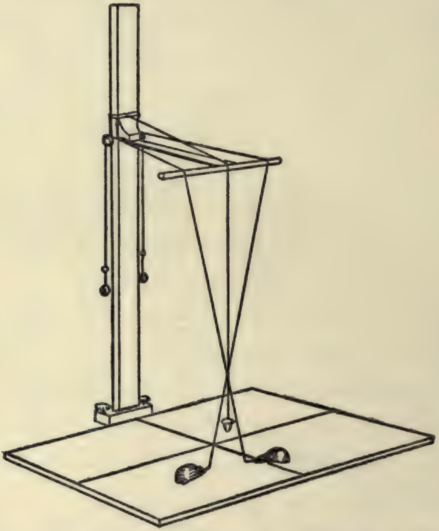


Fig. 56.—Diagram to illustrate the method of using the Mackenzie-Davidson cross-thread localiser.

The next step in the effort to aid the surgeon leads us to the combined method of localisation by radioscopy in the operating-room. For this a radiographic operating-couch is necessary, and it need not be very complicated if the localising apparatus is independent of the operating-table.

A simple table with an aluminium or three-ply top is sufficient when an apparatus such as that introduced by Mackenzie Davidson (or the localising apparatus of Signor Baese of Florence) is used. The latter has placed in our hands a most ingenious and accurate piece of apparatus.

The Mackenzie-Davidson method is that upon which a number of the methods at present in use have been based. It has the advantage that a screen localisation is possible by its use, or plates may be taken either above or below the couch. And in addition the plates may be used for stereoscopic projection, a useful confirmatory method in difficult cases. For exact localisation, as in cases of foreign bodies in the orbit and eyeball, or in the skull and brain, it is probably the most useful we possess. Dr. Sweet has introduced a procedure for eye localisation which is very useful when a large number of cases require to be examined.

Sir James Mackenzie Davidson, early in the history of radiology, called attention to the method which bears his name.

Briefly, it consists of the following procedure:

It is based on what is known as the triangulation method. So far as the actual technique is concerned, it consists of the taking of two radiograms of the subject with the foreign body *in situ*, from two different points of view.

The estimation of the depth may be ascertained by using the cross-thread localiser of Mackenzie Davidson, or by a reference to a table previously prepared for the distance and tube shift employed.

This method exactly reproduces the conditions under which the localisation was carried out.

The distance between the anti-cathode and the surface of the plate is exactly the same as that between the projecting arm and the glass plate upon which the objects are drawn. The two threads represent the paths of the rays in the two exposures—*i.e.* the development of the tube in the two positions. The pointers to which the free end of the threads are attached are placed upon a corresponding part of the two shadows of the foreign bodies. The threads are seen to cross at a given point that represents the position of the foreign body in space.

The depth may be measured in centimetres and millimetres or in inches, and recorded for the use of the surgeon.

THE ADVANTAGES OF STEREOSCOPIC RADIOGRAPHY

The stereoscopic method has the great advantage possessed by all plate methods, namely, the securing of a permanent record of the foreign body and its position in the patient. This enables us at any time to produce the plates and demonstrate the position of the foreign body.

It is perhaps most useful in the examination of the bones and joints after injury. The nature of the displacement can be accurately shown and an indication received for the correct treatment. After the reduction of a dislocation or a fracture another examination will show whether the injury has been correctly treated.

The stereoscopic method may also be employed in the examination of the internal organs, for the localisation of disease.

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